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Cooperatives and the Common-Pool Resource Game

Revisiting the experimental evidence

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Abstract

Common-pool resources are a necessity for human life on this planet, however many of them also face destruction. Fish stocks and the ozone layer are just some examples for common-pool resources, which are endangered, and the effects of their destruction will be felt globally. As sustainability, sustainable development and environmental protection enter global public discourse among large parts of modern society, investigating possible ways to conserve common-pool resources is important.Within this thesis I will examine evidence whether the model of cooperative organizations may be suited to more sustainably handle these resource systems. The findings indicate that cooperative organizations may have positive effects on sustainability efforts, however the evidence is not conclusive.

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1. Introduction

The goal of this Thesis is to research whether a cooperative organization of Common-Pool Resources may lead to positive outcomes and conservation of the common-pool resource. Common-pool resources are goods, which exhibit a high subtractability and where it is also difficult to exclude potential appropriators. (Ostrom et al, 1994) Cooperatives are a type of organization, in which the benefits of its members are the highest priority. (International co-op alliance) Due to the high subtractability of Common-pool resources it is important to treat them in a sustainable way and many common-pool resources are at the core of global conversations about sustainability. For example, the Ozone layer would constitute a common-pool resource, but the term will be more clearly defined in Chapter 2.

Sustainability, sustainable development and understanding our planetary boundaries are a large part of current culture. The United Nations sustainable development goals from 2015 set a pace, which the countries and leaders of the world should follow: To fulfill all 17 sustainable development goals by 2030. Some of these 17 goals are socio-economic, for example ending poverty, others are environmental, like clean water and climate action, while the last goal is calling for cooperation between member countries in order to reach these goals (United nations, 2015). These sustainable development goals lead political changes through agreements like 2015s Paris Agreement, of which the goal is to reduce emissions and decrease the temperature impact of climate change.

Meanwhile there is a rise of kids fighting against climate change across the world, "Fridays for Future" is a global protest movement initiated by students in the hopes of forcing politicians to act on the United Nations sustainable development goals. (Fridays for Future) What started out small in Sweden quickly took over the entire world and has spread far more than just young people protesting, as there have been large scale global climate strikes in part due to Fridays for Future. These protests became so large that Greta Thunberg, the initiator of Fridays for Future, was invited to hold a speech in front of the United Nations council, even though she was only 16 years old. (UN News)

In Germany the effects of bringing sustainable development and climate change into the public discourse are also noticeable. In the most recent European parliament election, the green party, which has long stood for climate action, surged to become the party most voted for by young voters, those between the ages of 18 and 24, with almost 35 percent among them. Furthermore, they became the second most voted for party regardless of age, with 20,5 percent of all votes, which is almost double the result of 2014, in which they were in third place with 10,7 percent of all votes. (Bundeswahlleiter, 2019)

Sustainability has also been classified a "megatrend", a "societal and economic shift" by the Harvard Business Review since 2010. Megatrends were first defined by John Naisbitt in 1982 and today sustainability is affecting businesses globally, both through laws and guidelines they have to keep, as well as advantages in comparison to their competitors as consumers grow increasingly conscious of the goods they buy and consume, as well as their environmental footprint. (Lubin et al. 2010)

For all intents and purposes this Thesis has its main focus on environmental sustainability, examining the usage and exploitation of common-pool resources, however where findings may indicate positive or negative effects on other forms of sustainability, I will of course mention these as well.

The effects of cooperatives on sustainable development and sustainable handling of resources are often said to be beneficial, especially by representatives of cooperative organizations. (Zentralverband deutscher Konsumgenossenschaften) Examining this effect through an experiment, while also comparing it to real life scenarios is the main driver behind this thesis.
The leading hypothesis is that cooperatives with their focus on the long-term benefits for its members would take a sustainable approach to handling common-pool resources in order to guarantee long-term use of it in comparison to higher short-term profits.

2. The Tragedy of the commons

In this chapter I will cover past research into the "commons" and "common-pool resources". The term *"The Tragedy of the commons"* was first established by Hardin in 1968, which in return references William Forster Lloyd's "*Two lectures on the checks to population"*. I will first give an overview and definition of the necessary terminology then cover historic research into the topic. Lastly, I will show experimental research as well as game theoretic approaches to the topic.

2.1 Common-pool resources

"Commons" as defined by Hardin, are resources, which are jointly used. Hardin used the following example to demonstrate what commons are and why he chose to call his work *"The tragedy of the commons"*:Hardin described an open grassland, which is the commons, and herdsmen as the appropriators. The appropriators will try to maximize their own personal gain and will attempt to add more cattle to their herds, which should give them a higher overall yield, however letting more animals graze on this specific meadow will result in overgrazing, the negative effects of which will affect all other herds as well. Hardin explained it mathematically, that adding one animal to one's own herd will provide positive utility close to +1, while the negative effect on the pasture is –1 shared between all appropriators, as now everyone besides the original herdsman, that received the +1, suffers from negative effects, they will also be inclined to add another animal to their herd in order to now once more maximize their own personal gain. This will further spiral the negative effects and as Hardin put it: "*Therein lies the tragedy. Each man is locked into a system that compels him to increases his herd without limit-in a world that is limited." (Hardin, 1968)*.
Since then observations of such resources and possible options to adverse tragedy have been researched in a variety of different ways. The most notable ones are the game theoretical research as well as real life field experiments and observations. The term common pool resource is used as a modern synonym for what Hardin referred to as commons.
This thesis is largely based on further research into the subject conducted by Elinor Ostrom and her collaborators. Her work on the common-pool resources earned her a Nobel prize for economics in 2009. (nobelprize.org) In her 1994 book "Rules, games and common-pool resources", she conducted game theoretical research into the field of common-pool resources. Common-pool resources as she defined them are "resource systems" in which it is difficult, but not impossible, to exclude or limit appropriators and the resource is subtractable. Examples to show the underlying problems chosen by the original authors were fishing ships from Brixton Harbor in England, where in the first six months of 1991 a lot of Fishermen died at sea, a sudden rise in deaths, which was attributed to the economic situation leading Fishermen to take more risks. (New York Times, 13 September 1991) The second example named by the original authors

were the geothermal generators set up north of San Francisco in 1991, even though enough generators were set up to produce 2043 megawatts of power, they only produced about 1500 megawatts, and the reason for this was that "The earth beneath those northern California mountains is running dry". (Science, 12 July 1991, 134)
These examples all were showing seemingly tragic outcomes for their respective problems, however "The Geysers" as they are referred to nowadays are still operating today with a capacity of 900 megawatts. (power-technology.com) As the geysers started to deplete in the 1990s some generators were shut down and decommissioned and starting in 1997 wastewater is being used to replenish the geysers. (Calpine Corporation)
This example shows that even a common-pool resource problem, which seemed to approach certain disaster, can be solved by reducing the number of appropriators and taking steps to conserve the common-pool resource. The general definition of common-pool resources as proposed by Elinor Ostrom and her husband Vincent Ostrom can be seen in the following definition Matrix:

	Excludable	Non-excludable
Subtractable	Private goods Clothing	Common-pool resources Fish stocks
Non-Subtractable	Toll Goods Pay-TV	Public goods Knowledge

Fig. 1, A general classification of goods (Source: Ostrom et al. 1994), Own examples

As you can see common-pool resources are classified by being non-excludable and subtractable. Excludability refers to how easily you can exclude someone from using a certain good or resource and rivalry means that if someone uses a specific good, then someone else will not be able to use it for its full potential as well.
Investopedia summarizes that knowledge and defines a common-pool resource as *"a resource that benefits a group of people, but which provides diminished benefits to everyone if each individual pursues his or her own self-interest. The value of a common pool resource can be reduced through overuse because the supply of the resource is not unlimited and using more than can be replenished can result in scarcity. Overuse of a common pool resource can lead to the tragedy of the commons problem."* (Investopedia, 2019)

2.2 Game theoretical research of CPRs

Game theoretical research into the topic of common-pool resources was conducted by Elinor Ostrom, Roy Gardner and James Walker in their 1994 book "rules, games and common-pool resources". The original work is the basis for the research conducted within this thesis, as noticeable in the previous chapter already and further in chapters 4 and 5. Unless otherwise noted everything following refers to the original work's chapter 3.
Ostrom et al. (1994) developed an investment game, which is explained in more detail in chapter 4.2, however they have also attempted to examine common-pool resource problems in other

ways. One early example for a common-pool resource assignment game is that of a fishing ground with 2 known fishing spots. Fishing spot 1 has more value than spot 2 and there are two players. The players must decide simultaneously and without knowledge of the other players' decision, where they want to fish. The distribution between the fishers is that they will receive the value of the spot divided by the number of fishers choosing to fish there. The specific strategies the players may follow depend on the values chosen for both spots.
Another problem they have found in common-pool resource systems is that of resource provision. A proposed game to examine this problem was to again take 2 Players which must decide whether they invest a "Token" they have, or not. Both players will receive a payout "v" for each Token invested, so if both players invest, they would both receive the value of 2v. The Tokens also have an outside value of "w", which a player will earn if they decide to not invest their Token. If player 1 invests their token, but player 2 decides to keep theirs, then both players would receive "v" and player 2 would also receive "w". The authors likened the strategy for the values 2v>w>v to a prisoner's dilemma game, as each player is incentivized to not contribute, but both benefit if they do.
There were also examples given for monitoring and appropriation externality, however as the authors noted, all of these examples are played out exactly once, while many common-pool resource dilemmas reoccur, for example the assignment problem exists every time the fishers choose to fish. As such a repeated game makes more sense to examine CPRs. The result was a repeated investment game, in which 8 participants decide how much they are willing to invest into a CPR. The final design will be explained in detail in chapter 4.2.
There are also other researchers that were trying to examine CPR problems with a game theoretical approach. In the 1992 article *"Simultaneous vs. sequential requests in resource dilemmas with incomplete information"*, by David Budescu, Amnon Rapoport and Ramzi Suleiman, the authors took a different approach than Ostrom, Gardner and Walker. They were approaching the dilemma not through a game in which the subjects invest into a common-pool resource but instead request a part of it. The idea was that the common-pool resource has a value of X, which the players do not know for certain, but they were given a probability chart to predict it. The players would then request a value and only if the sum of all requests were less than the value of the resource, they were given that value, if they requested too much, the payout would be nothing. (Budescu et al., 1992)
Some of the first game-theoretical research can very likely be found in a simplistic way in Robyn Dawes "Social dilemmas" (1980), in which the author proposed two games, the "take some" and the "give some" games. In the "take some" game, three participants were each given a blue and a red chip, all players decide simultaneously to hold up one of the chips. When a player holds up a red chip, that player receives a payout of $3.00, while all other participants lose $1.00, and if a player chooses a blue chip that player will only receive $1.00. Dawes explained that all players will have the dominant strategy of holding up a red chip, leading to a "zero social product". In the "give some" game, five subjects must choose whether to keep $8.00 to themselves or give $3.00 to all other participants, resulting in a total payout of $12.00. Dawes likened it to the decision whether to invest in a public good or not, as the personal payout when giving is lower than when keeping it for themselves, yet it produces value for other participants. (Dawes, 1980)

3. Cooperatives

In this chapter we will look at cooperatives, what they are, what kinds exist, how they differ from each other, how their historical role in Germany was and how they affect sustainability efforts.

3.1 Cooperative organizations

Cooperative organizations are associations, in which individual persons voluntarily unite in a jointly owned and democratically controlled enterprise in order to fulfill their economic, social and cultural needs. According to the international cooperative alliance, cooperatives believe in *"self-help, self-responsibility, democracy, equality, equity, and solidarity",* with members supposedly holding the ethical values of *"honesty, openness, social responsibility and caring for others"*. (International Co-operative Alliance)

Merriam-webster defines cooperatives as *"an enterprise or organization owned by and operated for the benefit of those using its services",* (Merriam-Webster) while the business dictionary defines them as a *"Firm owned, controlled, and operated by a group of users for their own benefit. Each member contributes equity capital, and shares in the control of the firm on the basis of one-member, one-vote principle (and not in proportion to his or her equity contribution)"*

Based on these definitions we can abstract that cooperatives are economic actors, that are owned by multiple individual persons, which have equal standing within the cooperative. The main goal of a cooperative is to act for the benefits of its members.

Cooperatives exist in many different sectors, depending on where you live you might picture a certain sector as a primary sector for cooperatives, for example the agricultural cooperatives prevalent in Spain or a major credit union in Germany. These different sectors also have different types of cooperatives, for example agricultural cooperatives are mostly economic actors, where the role of the cooperative is to provide services like marketing, while a housing cooperative's main purpose is to provide housing for its members. (University of California)

To show exactly how cooperatives operate I believe it is important to look at an example, the "Energiegenossenschaft Darmstadt eG":

The cooperative was founded in 2011 in order to produce energy using renewable sources for its' members. According to their website, they see energy provision as a decentralized network in which energy is consumed locally and not transported long distances by a few large corporations.

In order to become a part of this cooperative potential members must invest 500€ to buy their share of the cooperative. It is broken down into 400€ as an investment into their projects and 100€ is the value of the share. All members get exactly 1 vote during the general meeting and a dividend may be paid out to all members.

The only financial responsibility for the members lies in this 500€ investment, they are not personally liable for losses incurred by the cooperative. Members may buy more than one share, however their voting rights will always remain at exactly 1 Vote. Anyone can become a member and there is no limit for the number of members they will accept.

Currently they are operating only solar panels in and around Darmstadt. The produced electricity is then being distributed to its' customers via the "Bürgerwerke", which is an association made up of many local energy cooperatives that are all producing 100% renewable electricity. The members of EG DA are not required to also be customers, so it is possible to simply invest into this cooperative without making use of its' products. (Energiegenossenschaft Darmstadt eG)

3.2 Role of cooperatives in Germany

Cooperatives have a long tradition in Germany, some forms of cooperatives have existed since the middle ages, while the cooperatives as we know and think of them today first rose to prominence during the 18th and 19th Century. (Genossenschaftsgeschichte.info)
Today cooperatives in Germany are referred to as "Genossenschaft" and the first examples of these were founded by Friedrich Wilhelm Raiffeisen and Hermann Schulze-Delitzsch in order to provide financial help for the rural and poorer population. (Deutscher Genossenschafts- und Raiffeisenverband)
German cooperatives were appointed UNESCO "Nationwide Inventory of Intangible Cultural Heritage" in 2016 (UNESCO, 2016), for the idea and practice of cooperatives. They say that the idea of cooperatives comes from Wales, but it was "adapted and shaped" in Germany by Hermann Schulze-Delitzsch and Friedrich Wilhelm Raiffeisen in order to provide low-interest loans to farmers and craftsmen. UNESCO claims that personal responsibility and solidarity are some of the main values of cooperatives in Germany and that they are an "effective structural element" of modern German society. According to UNESCO there are 21 million cooperative members in Germany as of 2016. (UNESCO)
The German Bundestag called cooperatives an "important part of the German economic system" in 2018 and says that there are now more than 22 million individual members of cooperatives in Germany, which is more than six times the number of shareholder in Germany, meaning that about every fourth German Citizen is a member of a cooperative. The largest sector for cooperatives remains the financial sector through credit unions, which have 16 million members, 30 million customers and revenue of more than 1.000 billion euros. (Bundestag, 2018)
While modern cooperatives started as credit unions, they are now widespread in many different sectors in Germany: The "Leibniz-Institut für Länderkunde" says that many of the new formed cooperatives in Germany are for renewable energy and health care services. (Leibniz Institut für Länderkunde, 2017)
In 2018 there were 869 cooperatives in the energy sector with 70% of them focusing on producing electricity using solar energy. (Deutscher Genossenschafts- und Raiffeisenverband, 2018) More details about this sector and the role of cooperatives within it follow in the next chapter.

Basis in German Law

Cooperatives as referred to in 3.1 are called "Genossenschaften", for which the definition and requirements are given in their own laws, the "Genossenschaftsgesetz" (GenG). Genossenschaften in Germany are noted by the suffix "eG" for "eingetragene Genossenschaft" or "registered cooperative". This law has first been approved in 1889 and the newest version is from 2006. According to the Genossenschaftsgesetz, a cooperative in Germany is a company for which the main goal is the social, cultural or economic benefit of its members. (§1(1)) There is a minimum of three members (§4), however there is no maximum. A cooperative requires a board of directors, as well as a supervisory board and only members of the cooperative may be part of either. (§9)
The size of the board of directors depends on the number of members of the cooperative and it represents the cooperative legally. Members are only allowed to leave a cooperative at the end of a fiscal year, however under special circumstances, this may also happen at other points in time. (§65)

Overall the German law gives a lot of freedom to cooperatives as many aspects of the cooperative, for example the required equity or the ownership of multiple stakes, is left to be chosen by the individual cooperatives, these regulations are set by the Satzung (statute) of each cooperative.
One difference to the definition in 3.1 is that in Germany the cooperatives are allowed to grant multiple votes to their members based on §43GenG, in which it says that only members that *"are benefitting the operation of the cooperative*" should be granted multiple votes, up to three, however when a change requires an approval higher than 75%, they will only have one vote. For cooperatives that consist of entrepreneurs, as defined in §14BGB, individuals may be granted votes for up to 10% of the total votes of a cooperative, however details are left to the statute of the cooperatives. Lastly cooperatives that are made up of other cooperatives, for example credit unions, may grant additional votes based on owned equity or other measurements.

4. Cooperatives and sustainability

Cooperatives have been linked to the topic of sustainability in the recent years, for example the international co-operative alliance says *"Cooperatives have always endeavored to enable people to have access to goods and services without exploitation – to realize their needs and aspirations. This has led them to pursue a convergence between economic, social, and environmental interests – building triple bottom line sustainability."* (International co-operative alliance)
They have also started a platform called "Co-ops for 2030" to show the contributions of cooperatives to reaching the Sustainable development goals set forth by the united nations, which is co-funded by the European union. (Co-ops for 2030) On this platform, cooperatives from around the world can pledge to fulfill sustainable development goals, for example the Japanese consumers' co-operatives pledge to reduce CO2 emissions by 40% until 2030.
Each of these pledges target either a specific SDG like in the example above, or try to solve multiple of them at once like this one from the "National cooperative business Association CLUSA International" in the United States of America: *"Through our Cultivating Nutrition program, we are committed to partnership capacity building in order to improve the quantity, quality, price, use, and governance of nutritious foods and increase women's resiliency to economic and climate-induced food insecurity."* They target food security and reducing inequalities. (Co-ops for 2030)
Mathias Fiedler, the representative of the Association of German Consumer cooperatives has said the following in 2016: "*Cooperatives are destined to act sustainable based on their core structure"* (Zentralverband deutscher Konsumgenossenschaften, 2016) by which he of course means the core principles of a cooperative, equality and responsibility. Monique F. Leroux, the president of the International Co-operative Alliance, has said in 2016 that cooperatives will play an "essential role in implementing the 2030 Agenda" due to them being "sustainable, people-focused businesses". (International co-op Alliance, 2016)
In Germany the link between cooperatives and sustainability has existed for a longer time now. Since 1971 the German state of north rhine-westphalia (NRW) has called on cooperatives to manage all fishing through laws. The "Landesfischereigesetz" or "state fishing law" regulates all fishing activities in NRW and it says that everyone with the right to fish in a given municipality is directly part of a fishing cooperative. Each municipality is one fishing district and every district

must have a cooperative, which is now responsible for all fishing within the district and must prevent the culling of local species and fish stock. (Landesfischereigesetz)
Fishing cooperatives do not only exist in Germany, they can be found worldwide. Some examples are the many cooperatives found within Alaska, like the "Seafood Producers Cooperative", which is the oldest fishermen's cooperative of North America and exporting its products worldwide to restaurants and within the USA through an online shop directly to consumers. Much like the cooperatives in Germany they are valuing sustainability with their motto *"One Hook, One Fish At A Time",* which is supposed to guarantee high quality seafood and conserves the fish stock for future generations. The benefits for its' members are the processing, marketing and other support services without relying on outside help. This helps the fishermen get fair prices for their catches. (Seafood Producers Cooperative)
Within Germany the previously mentioned energy cooperatives take pride in playing a large part in Germany's sustainability efforts. A detailed example of how these operate as economic actors can be found in Chapter 3.1. On a higher level there is the "Bündnis Bürgerenergie e.V.", which is an alliance of individuals and local energy companies and cooperatives, which believe in a decentralized network of regional energy suppliers. This alliance has 200 members, which are organizations, associations, networks and individuals, that represent more than 500.000 members in total.
They believe that economic goals should be of lesser importance than those that provide social benefits, for example environmental protection and sustainable development of regions. (Bündnis Bürgerenergie)According to the German cooperative association, the energy cooperatives have saved 3,39 million tonnes of greenhouse gases in the energy sector. (Deutscher Genossenschafts- und Raiffeisenverband, 2019)

5. Experimental research

The following Chapter details experimental research, which was conducted in cooperation with the Centre for sustainable economic and corporate policy.

5.1 Methodology

The experiments were conducted in the experimental laboratory of Hochschule Darmstadt. The laboratory equipment consists of 15 Subject PCs and a conductor PC, which all use Windows 10 and are connected to an internal Server within the laboratory. The software used for the experiment was the "Zurich Toolbox for Readymade Economic Experiments", which is a free to license Software package provided by the university of Zurich specifically for academic use. This software package consists of the server software, Z-Tree, which is running and controlling the experiment on the conductor PC, as well as the Client software, Z-leaf, which is running on the Subject PCs and connecting to the server of the conductor PC. Both programs used version 4.1.11.
For the Experiment we have invited Students and employees of Hochschule Darmstadt (Darmstadt University of applied sciences). The main focus of the recruitment was to try to get participants from the faculty of economics (Darmstadt business school), however, it is not guaranteed that only economics students participated in the experiment, as pamphlets were handed out across the campus, which may have lead to other students and employees participating in the experiment as well. Participation was free and there was no prior registration necessary, furthermore, we have not stored any personal information about any of the subjects.

After their participation, the subjects were paid according to their earnings during the experiment. Participants that showed up, but could not participate, were given a show-up fee and asked to return at a later time.
The experiments were conducted on the 30th and 31st of January 2020 in a timeframe between 9 am and 3 pm local German time. There were a total of four groups, each of eight participants, however, there were 7 participants, that participated in two rounds, more on that during the Data Description and Data Limitation Chapters, for a total of 25 unique participants. The participants always sat at the same PCs in the same client order.
During the experiment, communication between the subjects was not allowed and all questions about procedure had to be asked beforehand. Questions about the theme of the experiment, research questions, as well as questions about the math behind the experiment were not answered before and during the experiment. The subjects sat in two groups, three subjects on one side and the remaining five subjects on the other side of the room. Their backs were turned towards each other and there were dividing walls between each table to make sure that they could not see the actions of other participants.
The conductor sat at a separate large table with a large PC monitor in front of him, so that the participants could not look at the conductor screen or try to communicate with him during the experiment. Participants were told that they could leave the experiment at any time, however none of the participants chose to revoke their participation. After the successful conclusion of the experiment, the subjects signed a receipt, were paid and then left the room. The Data was then compiled and saved on the local server using Z-tree's built-in toolset and lastly analyzed using Microsoft Excel (2019).

6. Experimental Design

The experimental Design is based on the experimental Design of Ostrom, Gardner, Walker's "Rules, games and common-pool resources". In this book the authors have conducted research into CPR dilemmas and part 2 details the experimental research. The authors conducted experiments at Indiana University. I will first detail the original experimental design from this book and then show the one used in our current research.
The original design purpose is to see how individual actors treat a CPR dilemma. In this design there are eight subjects, each sitting at their own PC. The eight subjects were tasked with investing "Tokens". These Tokens have no direct real-world value, there is no conversion rate to them. The original design uses two sets of Tokens, for some groups the subjects were given 10 Tokens, in other groups every subject was given 25 Tokens in each round. After allocating the Tokens, the subjects were asked to choose how many of these Tokens they would invest on one of two markets. On Market 1 the Tokens were worth 5 Cent each and on Market 2 the Token value would change according to the total group investment. Subjects could approximate the value of their investment by reading a table they were presented with. The original table is visible in Fig. 2. The subjects were not told how many rounds they would play beforehand, they were only told that they would play more than 20 rounds. After every round the subjects would see their investments and earnings, as well as the total group investment in Market Y. The subjects were not able to see individual investments of other participants. The "earned" money was paid out in cash after the conclusion of the experiment.

Tokens invested by Group	Units of Commodity produced	Total Group return	Average Return per Token	Additional Return per Token
20	360	$3.60	$0.18	$0.18
40	520	$5.20	$0.13	$0.08
60	480	$4.80	$0.08	-$0.02
80	240	$2.40	$0.03	-$0.12
100	-200	-$2.00	-$0.02	-$0.22
120	-840	-$8.40	-$0.07	-$0.32
140	-1680	-$16.80	-$0.12	-$0.42
160	-2720	-$27.20	-$0.17	-$0.52
180	-3960	-$39.60	-$0.22	-$0.62
200	-5400	-$54.00	-$0.27	-$0.72

Fig. 2, Original Table presented to participants (Source: Ostrom, Gardner, Walker (1994) p.107)

The CPR dilemma in this experiment happens on Market 2. Individual subjects could earn a lot of money if their competitors would not invest or the group could earn a lot of money if they would cooperate to not exploit Market 2 too heavily. The optimal earnings every round were if the subjects would invest a total of 36 Tokens. In the original experiments this happened in no round.
This demonstrates a CPR dilemma, because we have a group of appropriators that all want to exploit a resource (Market 2) for their own personal gain. If they are too greedy, they will harm the CPR and thus reduce overall production for the whole group. One dimension is not displayed in this baseline experiment, as market 2 recovers after every round, it does not show long-term effects of individual round investments, which are an important factor when looking at how to treat CPRs, such as the Ozone layer, in a real-world environment.

Market 2 math:

Market 2 always reacted in the same way according to the following function:

$$F(x)=23*(C_i)-0.25(C_i)^2$$

C_i is the sum of all contributions to Market 2. The result of this function is the production of Market 2 in Cents, so for example a C_i of 50 would lead to a production of 525 Cents, or $5.25. To calculate individual earnings by each subject the following function is used:

$$F(x)=[23*(C_i)-0.25(C_i)^2]/(C_i/C)$$

In this original design the questions were how the subjects would act, react and strategize. It is worth noting that they were never told that this is a CPR dilemma, they were only told that they would decide between markets 1 and 2. Later designs from the authors include allowing different forms of communication, penalties and checking the destruction of the CPR.

Our Design

For our research we have taken the baseline experiment and added a new factor. We have decided to conduct some sessions using just the baseline experiment translated into German and renaming the markets. Market 1 is now called "Kapitalmarkt", capital market in English and Market 2 was referred to as a "Fischerei", a fishing company. These names were chosen as investing into different markets may not properly showcase that the subjects are investing into a specific resource system in Market 2 instead of trading on a market.
Fishing is an example given in the original as a typical CPR dilemma. The more you fish, the fewer fish will be remaining, leading to less production in the following cycle and if you fish too much you end up driving certain species to extinction, which is the destruction of the common pool resource.
Another change implemented in the narrative is that there were multiple groups that played as a cooperative in order to examine the main research question behind the thesis. There was one third design in which we provided a definition of a cooperative to the participants before conducting the experiment. The three designs are referred to as A, the original Baseline experiment, B, the participants play as a cooperative and C, the participants play as a cooperative and were given a definition of cooperatives.
Entirely narrative changes should not affect the math behind the experiment, the optimum, Nash equilibrium and strategies to maximize personal gain are left untouched, if players act rationally these changes should not affect the outcome of the experiment, however one hypothesis is that when subjects are directly presented with a scenario about sustainability, they might forfeit personal gain, another hypothesis is that when players are part of a cooperative, they will also act more cooperatively.

7. Data Description

In order to gather and observe the Data in this experiment we have used the Zurich Toolbox for readymade economic experiments. We had four experimental sessions with each of these sessions having had 8 participants. Each session lasted for 20 played rounds; thus we have observed 640 individual choices and 80 group results. Due to a scenario more closely described in the following chapter, we had to cut the data down to only 3 groups, thus we are left with usable Data consisting of 24 participants, 60 group results and 480 individual choices.
As all three groups played with different versions of the experimental design, Group 1 played version A, group 2 version B and group 3 version C, we are left with only one group, 8 participants, 160 individual choices and 20 group results for each experimental version.
In order to more easily compare behavior, I have calculated the average Investment for the "quarters" and "halves" of the session. This corresponds to the number of rounds that were played, so when I mention the "second half" that will refer to the average Investment in rounds 11-20. The quarters are rounds 1-5, 6-10, 11-15 and 16-20.
You can find a complete Data table of the sum of contributions under general observations.

Group 1

Group 1 played our version of the Baseline experiment. The only difference to the original design was translating the instructions to German and renaming the markets.

Group 1 had an average sum of contributions (SumC) of 57,35 invested Tokens. The value of SumC had a minimum of 46 and a maximum of 67. The minimum was observed only once in Round 3 and the maximum has been observed twice, once in Round 14 and once in Round 17. When looking at the overall investment one thing becomes clear, the average investment was gradually increasing throughout the game. In Rounds 1-5 there was an average sum of contributions of 52,6 Tokens, while in Rounds 16-20 the average group investment was 60,2 Tokens. There was only a single round in which the overall group investment was the same as the round directly preceding it, rounds 7 and 8 had an Investment of 53 Tokens, however the individual Investment choices changed between them.
In terms of individual Investment choices, there was an increase of average investment in the second half of the session for almost all subjects. The only subject, which decreased their investment was subject number 2 and we can observe a gradual decrease in invested Tokens. In the first round Subject 2 invested 7 Tokens and invested +-1 Tokens until Round 7 in which they changed their strategy and started investing only 5 or fewer Tokens. In Round 6 the total group investment reached 60 Tokens for the first time, which may have affected the change in strategy. The only round after that in which Subject 2 invested more than 5 Tokens was in Round 17, where they invested 8 Tokens. It is important to mention that Round 16 was an "average" round so the change in strategy was not prompted by a low previous group Investment. After round 17 they invested only 5; 3 and lastly 2 Tokens. The only subject that did not see an increase in the second half of the experiment was subject 6. Subject 6 invested 7 Tokens in the first round and beginning in the second round only invested 10 Tokens until the end of the experiment. The only other subject that played at the same investment level for more than 5 rounds was subject 1, investing 8 Tokens from round 12 to round 18. Subjects 2, 3 and 8 never played more than two rounds in a row with the same Investment.
The Nash equilibrium of 64 Tokens was not observed and neither was the maximum group profit at an Investment of 36 Tokens. At the end of the game subject 6 was rewarded for keeping the Investment at 10 Tokens by having the highest personal payout, 114% of the average payout, and subject 2 was "punished" for their low investment by having the lowest personal payout, 87% of the average payout. The average payout for this group was 15,07€.

Group 2

Group 2 played the same game as Group 1 only with the addition that the fishing company was called a "fishing cooperative".
The average sum of contributions for group 2 was 53,4 Tokens. In the first 5 rounds the average was 47,4 Tokens and in rounds 6-10 that increased to 55,6 Tokens. For the rest of the experiment the average investment level stayed around 55 Tokens. The first investment was 38 Tokens and the second round only saw an increase to 44 Tokens. Round 3 was the first round with an Investment of more than 50 Tokens. There was only one more round with a group Investment of less than 50 Tokens, round 4 with 47 Tokens. On the other end of the spectrum, there were only two rounds in which the sum of contributions was higher than 60, rounds 10 and 16, both with the highest total investment of 63 Tokens.
Individual Investment decisions paint a more interesting picture. Subjects 1 and 4 slightly increased their average Investment in the second half, subject 1 invested 0,5 more Tokens on average and subject 4 only invested 0,3 more Tokens on average. Looking at subject 1 in closer detail reveals that they invested more than 6 Tokens in three rounds, 7 Tokens in round 4, 8 in

round 7 and a sudden spike to 10 Tokens in round 19, however all three rounds saw a much lower investment in the following rounds, dropping to 3, 2 and 5 Tokens respectively. Subjects 3 and 6 decided to only invest 10 Tokens in every round in the second half. Subject 3 changed their strategy in round 8 and subject 6 in round 10. Subject 2 invested only 3 Tokens in the first round and started investing only 5 or more Tokens in round 4. The average Investment for rounds 5-10, 6-15 and 16-20 remained constant at 6,8 Tokens. In order to keep the average sum of contributions at the same level, subjects 5, 7 and 8 reduced their average Investment in the second half of the session. Only a single subject invested no Tokens for a single round, subject 6 in round 7. As they invested 10 Tokens in both round 6 and round 8, this decision is a clear outlier. In this group there was not a single round played at the Nash equilibrium and no round had an Investment of 36 Tokens either. The average payout for this group is 16€, but this average is skewed by subjects 3, 4 and 6 having a payout of more than 17€. Subjects 1, 5 and 7 earned less than 15 € in comparison. Subject 5 had the lowest payout, 91% of the average, while Subject 3 had the highest payout at 112% of the average payout.

Group 3

Group 3 had the same experiment as Group 2, only with the addition of being shown a definition of a cooperative in the instructions.
The average sum of contributions for Group 3 was 49,6 invested Tokens, but there is a gradual increase in total invested tokens, ranging from 45 Tokens in the first five rounds to 53 Tokens in the last five rounds. Looking at individual rounds, the highest total amount in the first quarter was 50 Tokens, reached in round 4, after which there was a decrease down to 42 Tokens again. This led to the group reaching its highest total investment in round 6: 62 Tokens, which saw an even bigger decrease down to only 37 Tokens in round 7. This behavior of a high investment round leading to a low investment round can be observed through the entire session.
Comparing the individual behavior of the participants we can see that there were four subjects, which invested more Tokens in the second half of the game, two subjects decreased their average invested Tokens and the remaining two subjects kept almost constant throughout the session. One noteworthy observation is that subject 2 started investing exactly 4 Tokens in round 7 and chose differently only twice, in rounds 12 and 13, for the rest of the game. In those two rounds they reduced their investment to only 3 Tokens, before increasing it back to 4 Tokens again. Subject 3 invested only 10 Tokens starting in round 12. All other subjects did not invest the same number of tokens in more than 5 subsequent rounds.
No round was played at the Nash equilibrium or optimum in this group and the average group payout was 16,74€, subjects 1, 2 and 8 had a payout lower than average, while all other subjects had a higher payout. Subject 1 had the lowest payout at 81% of the average payout and subject 5 had the highest payout with 115% of the average payout.

General observation

Neither the Nash equilibrium, at which 64 Tokens would be invested with every player investing exactly 8 Tokens, nor the "optimum", at which exactly 36 Tokens would be invested in the fishing company, were played even once across all three sessions.
The following is the complete Data Table for the sum of contributions of all three groups:

Round #	Group 1	Group 2	Group 3
1	51	38	42
2	59	44	46
3	46	52	45
4	52	47	50
5	55	56	42
6	60	58	62
7	53	54	37
8	53	52	47
9	66	51	46
10	58	63	53
11	57	53	55
12	58	52	54
13	54	58	47
14	67	54	51
15	57	58	50
16	58	63	56
17	67	52	51
18	65	57	58
19	56	53	51
20	55	53	49

Table 1, Sum of Contributions

After every session the participants asked the following questions: "Who earned the most money?" and "What was the optimal number of Tokens for the highest payout?".
11 participants replied in the questionnaire that they knew what a cooperative was previously, however only two subjects have been part of a cooperative before. Due to privacy regulations there is no way to track exactly which subjects they were, so I can not say "the members of cooperatives played more cooperatively", however they were part of groups 2 and 3. In groups 2 and 3 at least 4 participants knew of cooperatives beforehand, while only 2 subjects in group 1 were familiar with them.

8. Data Limitations

Even though our findings might be interesting they also have a lot of limitations.
Firstly, the framing of the experiment was changed considerably. Framing of an experiment has long been shown to influence the behavior of participants and our observed variable lies in the framing as well, the observation whether the term "cooperative" has any effect on the behavior of participants.
There was however also a second change to the framing of the experiment in the definition of investment possibilities. In the original work by Ostrom, Gardner and Walker, the two Investment opportunities were merely called "Markets" a very wide and general term, which might mean anything from the stock market to a local flea market, depending on what the participants may have associated with it. In our experiment we have changed it to refer to the Capital Market and a fishing entity instead. By calling Market 2 a fishing entity of some sort, it may have had the

effect that our participants could be familiar with the topics of sustainable fishing, overfishing and even fishing cooperatives as they exist in Germany.
This may have influenced personal behavior in a way, which is not trackable by the observed Data and makes the two Datasets, the original from 1994 and our observations in 2020, not entirely comparable and is something that should be kept in mind in the analysis of the Data.
On that note, it is important to keep in mind that our experiments were observed in 2020, years into sustainability as a megatrend and a constant topic of discussion in public discourse, as illustrated in Chapter 1. Simply the difference in public awareness of sustainability as a topic may have already influenced the behavior of our participants in comparison to 1994, where sustainability was not yet a theme of everyday life. As we can see in Chapter 1 sustainability is also a topic pushed by younger members of society, as evidenced by the election results and the "Fridays for future" movement, as the majority of participants in both 1994 and for this Thesis were recruited from students of universities, this could mean that our students are more active in discussions around sustainability, which may have had an effect on their choices during the experiments.
Furthermore Hochschule Darmstadt is also doing a lot of work in the field of sustainability, for example this Thesis was written in cooperation with the "Centre for sustainable corporate and economic policy", a research institution of the faculty of economics with a focus on topics important in sustainability and its effects on businesses and society. There is also an initiative at the university called "initiative: nachhaltige Entwicklung" (i:ne) in which the university is collaborating with regional partners to research and enact sustainable policies and other actions. The sustainability movement at Hochschule Darmstadt takes such a center role at the university that one of the offered PhD programs is in "sustainability sciences". The fact that all participants in the experiments are affiliated to this university may have also affected their choices during the game.
The biggest limitation however is the sample size. There were only 3 usable groups of participants, while a sample size should always be "as big as possible", according to Andreas Hellmann, Senior Lecturer at Macquarie University, participants should be selected to represent the population and at least 30 participants should be observed for every condition. (Hellmann, 2019) Our sample only consists of 24 participants, and because it skews towards younger participants does not properly represent overall population, because there were participants, which were not students, but instead employees at Hochschule Darmstadt, it is also not a representative sample for the population group "students".
A final limitation was that there were participants that have already participated in preview tests of the final experiment and, in some cases, were part of the planning and design team of the experiment. There was also one group, a fourth experimental group, which mostly consisted of participants, that had already participated in a prior session. The results of this fifth group simply has proven that with communication and coordination outside of the laboratory environment, participants could achieve high group profits. These subjects were all seemingly friends and everyone followed the rules set out by them, to maximize group payout. Based on a conversation I observed before and after the experiment, they may have ignored the new instructions and simply clicked through all of them quickly in order to earn money faster. I have decided to omit the Data observed in this group entirely as a result of that.

9. Experimental results

In this chapter I will analyze the Data described in the previous chapter and compare it with already existing literature.

9.1 Comparing the observations

As illustrated in Chapter 4.3 all three groups acted very differently over the course of the experiment. The average individual payout serves as a good first comparison point, as it sums up the difference in behavior quite nicely: Group 1, the baseline group, has earned the lowest average payout, while group 3, the cooperative group, which received an explanation of cooperatives, has achieved the highest payout. This is a result of the overall higher Investment level of group 1 and low investment level of group 3.
This might be an interesting finding, that cooperative players are able to maximize their profits more easily, however when looking at the distribution of the payouts, we can see that in group 1 there were only two outliers and the remaining participants were all receiving payouts close to the average, while in group 3 there was only a single payout within 1€ from the average, all other participants either earned a higher or lower amount of money. This is evident when comparing the standard deviation for both groups, with group 1 having a deviation of 1,19€, while group 3 has an almost doubled deviation of 2,35€. This deviation shows that the participants in group 3 "exploited" the behavior of those that chose to invest only few Tokens, while the same attempt was made in Group 1, due to the higher level of average investment, it yielded lower results.
One interesting comparison would be to look at the two highest earning players, subject 6 in group 1 and subject 5 in group 3:

	Final payout	Average Investment	Rounds with 10 invested Tokens
Group 1, Subject 6	17,17€	9,85 Tokens	19
Group 3, Subject 5	19,22€	8,4 Tokens	7

Fig. 3, Comparison of subjects with the highest payout

As you can see, despite having a lower average investment and less rounds with the maximum number of tokens invested, subject 5 of group 3 has received a higher total payout. Comparing the two lowest payouts of both groups provides similar results, with group 1, subject 2 having invested 4,3 Tokens on average with a final payout of 13,18€ and subject 1 of group 3 has received a final payout of 13,52€ with an average investment of only 3,35 Tokens.
While the overall payout is in ascending order between the three groups, 121€, 128€ and 134€ respectively, the average level of group investment decreased between the three groups: 57, 53 and 50 Tokens on average.
In terms of group investment, group 1 also had the highest amount in the first round, 51 Tokens, and the highest amount in the final round with 55 Tokens. Furthermore, it had the highest maximum sum of contributions in rounds 14 and 17, having invested 67 Tokens, as well as the

highest minimum: 46 Tokens. Meanwhile group 3 had the lowest maximum of all groups with 62 Tokens, the lowest minimum with 37 Tokens and the lowest final round with 49 invested tokens. The following figure compares the sum of contributions between the three different sessions:

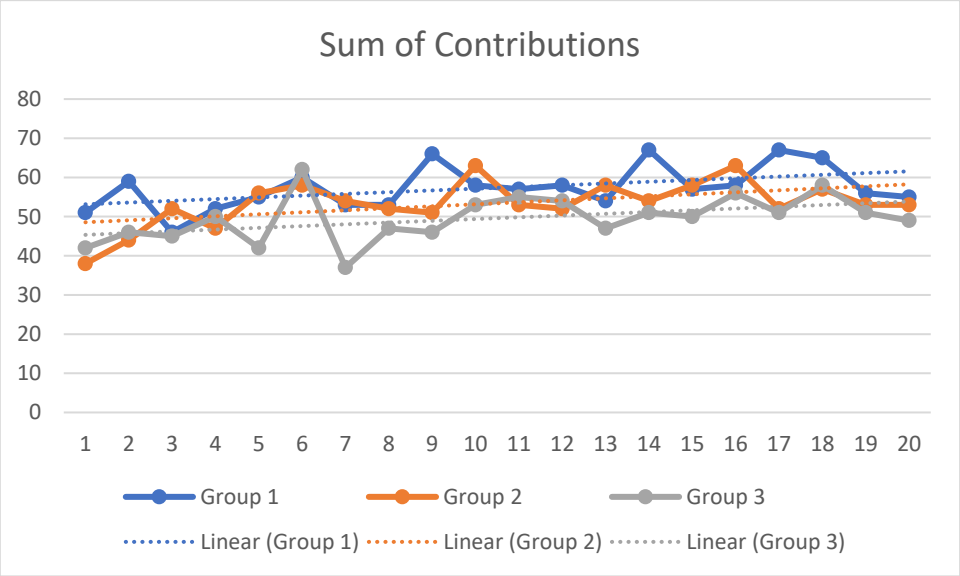

Fig. 4, Sum of Contributions

As you can see through the Trendline, all groups invested more Tokens as the session went on and even though group 2 seems to have found an investment level they were trying to keep, as their average sum of contributions is around 55 Tokens in three quarters of the experiment, there was a small increase in the last quarter, due to the decisions in round 16. I can only assume that if the sessions would have lasted for a longer period of time, that the average investment would have also increased on a group level.
Looking at individual investment decisions, we can see that investing 10 Tokens was the most popular choice, they were invested 117 times throughout the three sessions, meaning that 24,4 % of all decisions resulted in a 10 Token investment. The least chosen investment was to invest no Tokens in the fishing company, this was only chosen 6 times, twice in each session. These two findings were the same for each individual group, however when looking at the other choices we can see clear differences. The second most popular choices were 8, 5 and 4 Tokens for groups 1, 2 and 3 respectively. Interestingly, no other decision but 0 had the exact same number of investments in all three groups, however in both groups 1 and 2 there were 20 decisions to invest 7 Tokens.
In all three groups there was at least one participant that invested less in the second half than in the first half, however in all groups there were more participants that chose to invest more in the second half.

10. Comparison to original Data

Data observed in the original work by Ostrom et al. will be referred to as "original Data" in this chapter, while the Data observed in our experimental research at Hochschule Darmstadt will be referred to as "new Data".
Before doing any comparison, it is important show the original Data first:

Round #	Group 1	Group 2	Group 3
1	62	57	55
2	68	59	57
3	70	60	62
4	62	65	54
5	66	53	59
6	62	61	63
7	72	60	56
8	71	65	65
9	72	64	71
10	65	62	62
11	68	56	53
12	68	63	63
13	74	63	64
14	63	70	66
15	72	64	63
16	73	60	64
17	66	60	70
18	59	64	64
19	71	59	64
20	64	63	68
21	64	61	63
22	69	62	66
23	66	68	62
24	62	60	66
25	65	62	70
26	67	64	66
27	68	58	64
28	70	62	70
29	73	68	66
30	63	60	70

Table 2, Original 10-Token Baseline experiment results (Source: Rules, Games and common-pool resources, Ostrom, Gardner Walker (1994) p. 128)

This data was taken from the original Baseline experiments using 10 Tokens only, as other experimental groups used different rulesets, for example that participants could communicate or that they used a different number of Tokens. This led to there only being three groups that played a similar game as our participants.

The original authors recruited economics students from Indiana University and we recruited all of our participants at Hochschule Darmstadt, with a focus on those affiliated with the faculty of economics, so the data should be comparable.

The original three groups had an overall average of 64,16 Tokens invested in each round, which is almost 7 Tokens more than the new group with the highest average. The original groups had an overall minimum investment of 53 Tokens and a maximum of 74 Tokens, while the overall average of the new groups was 53,45 Tokens, so the minimum, which was only played in a single

round (group 3, round 11) is the average for our new observations and the maximum of group 3 is lower than the average of the original data.
This following chart shows the sum of contributions for the original three groups:

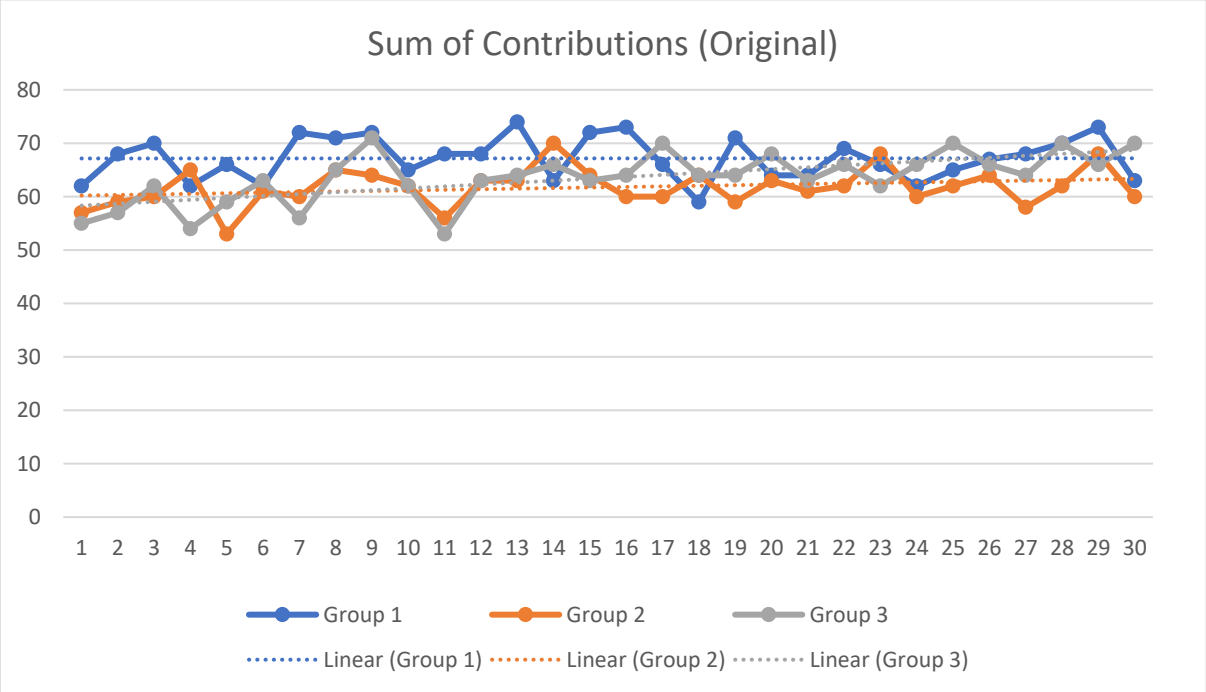

Fig. 5, Sum of Contributions (Original), (Source of Data: Ostrom et al. (1994) own visualization)

Interestingly, comparing the Trendlines with our new results, they appear flatter, however when calculating the slope of the individual Trendlines, we get the following results:

Group 1	Group 2	Group 3	Group 1(new)	Group 2(new)	Group 3(new)
0,005	0,647	1,188	0,499	0,523	0,447

Table 3, Trendline slope

As we can see, the original Data is having much higher variations than our new one. There is a chance this result is changed by the fact that the original participants played the game for 10 more rounds than in our design, so trimming the Data of the original by the last ten rounds we are left with the following results:

Group 1 (trimmed)	Group 2 (trimmed)	Group 3 (trimmed)	Group 1 (new)	Group 2 (new)	Group 3 (new)
0,116	0,495	0,707	0,499	0,523	0,447

Table 4, trimmed Trendline slope

The findings remain largely the same, both groups 1 and 3 have a very different slope than our new observations. Comparing the progression of the average sum of contribution like in chapter

4.3 provides similar results as found in the new data, it is steadily increasing, when comparing in batches of 10 rounds. Group 1 seems to be the only outlier as there was only a small increase of less than 1 Token between the first 10 rounds and rounds 11-20 and in the last ten rounds there was even a drop, with 66,7 Tokens invested on average, it is the lowest average of that specific group.
When looking at the sum of contributions the original authors described it as a "pulsing pattern" in which the sum of contributions would increase, which in turn reduces the personal payout, and then led to a decrease in Investment, which would then again result in an increase. We were able to observe the exact same behavior, where after what might be perceived by a group as a "high investment round" there was a drop in investment, which then increased again. The most notable example found in the new Data would be Group 3's round 7, where the investment dropped from 62 Tokens in round 6 to only 37 Tokens in round 7. This extreme decrease of about 40% was not observed in any other groups, so it is safe to call it an outlier.
Interestingly the original authors observed 10 rounds in which the sum of contributions was exactly 64 Tokens, while we did not observe a single round. This may be due to the lower overall investment level found in our new groups in comparison to the original data, for which the average is close to 64 Tokens. Much like the original authors we were also not able to observe a single round played with the optimum.
Comparing individual investment decisions, Ostrom et al. found that in the last five rounds many subjects would always invest the same number of Tokens, but as we played fewer rounds, this will be difficult to compare, a more interesting comparison would be that they also had 4 participants that invested 10 Tokens in every of the first five rounds and 3 participants that invested 10 Tokens in every round they played. (page 120, Table 5.3) In our new data there was not a single participant that only invested 10 Tokens throughout the entire game and neither was there one that chose to invest only a specific number of Tokens in the first five rounds. Interestingly there was not a single subject, which invested only a specific number of Tokens in the first 5 rounds.

11. Conclusion

11.1 Can cooperative organizations benefit common-pool resources?

Coming back to the Hypothesis, that cooperatives would benefit common-pool resources, the answer may not be as conclusive or easy as the evidence and cooperative opinions may suggest. First, we need to look at the common-pool resources themselves. When defining common-pool resources and public goods, the difference may be situational: Clean water is classified as a public good by the German federal ministry for the environment, but according to the world health organization, 2.2 billion people lack access to safely managed drinking water, and it forecasts that by 2025 half of the world's population will be living in "water-stressed areas", due to the effects of climate change, water scarcity, population growth and other factors. (World health organization, 2019)
This shows that what may be considered a public good in one region of the world is, in fact, a common-pool resource elsewhere. The effects of climate change may also result in resource systems becoming CPRs, which are currently considered public goods, or which may be thought of as non exhaustible by the general population.

Another difficulty when investigating common-pool resources is that effects of single actors may not be fully measurable, as there might be other appropriators and the effects of the exploitation may only become noticeable after time passes.
As a result, investigating the specific effects of cooperative organizations on common-pool resources is difficult. It is almost impossible to measure whether a cooperative is managing it better than a "traditional" company, because there would need to be two scenarios:
A) Only let cooperatives manage a common-pool resource and
B) Let only other types of Organizations manage the common-pool resource.
A case of A) exists in the fishing cooperative in NRW to a degree, however there are strong regulations in place, for example catch limits of certain species, which would affect other types of organizations in similar ways. Another problem is that according to the association of fishing cooperatives of NRW "Verband der Fischereigenossenschaften Nordrhein-Westfalens e.V", there are still some fishing grounds without cooperatives in place. So, the actual effects of the cooperative organizations on fish stock are not measurable anymore.
Because of that I will use overall environmental and social sustainability efforts of cooperative organizations as a proxy, in order to assume, whether there may be a positive effect on common-pool resources as well. I emphasize the word "assume", there is no conclusive evidence either way and all findings should always be open to critical thinking, what I present are not facts, but merely observations in this study.
As demonstrated in earlier chapters, cooperative organizations pride themselves in valuing their core beliefs more than maximizing their profits. Looking at individual cooperatives their "core values" may differ, so I choose to look more deeply at the values of "responsibility" and "equality", as those are at the core of every cooperative through the voting rights of every individual member.
Looking at equality within a cooperative, it will usually mean that every member has the same right to have one vote during the general meeting, it also means that every member has to invest an equal amount of money into the cooperative to become a member. However, "equality" is also a value that I have found to be more loosely interpreted: Cooperative members have the option to invest more money in order to acquire more financial stakes. Even if the voting power remains at the one vote, one member principle, some cooperative members having more financial stake within a cooperative does not make all members equal.
Looking at equality in a broader scale, there is of course the sustainable development goal 10, "reducing inequalities", which mostly refers to the gap between the rich and poor and examining this in detail would make for another research topic, there was however one point when examining cooperatives, where I felt that it was ironic: Many cooperatives act for the benefits of its members, not for the entire society.
Of course, cooperatives like energy cooperatives have a positive effect on greenhouse gas emissions, which in return benefits everyone, but for example housing cooperatives, which claim to provide "affordable housing", apply the term "equality" only for their members. Becoming a member usually depends on being able to invest a sum of money into a cooperative, so a cooperative, which might operate with the goal of providing "affordable housing" requires all potential members to first invest a large sum of money to then be able to make use of the affordable housing, which in turn excludes many people that may require affordable housing. This does not reduce inequalities, it may accelerate them, as "affordable" living space will now be restricted behind membership, membership that depends on being financially well-off

enough to be able to pay the membership fee, the cooperative shares and then also the rent of the apartment you chose. Of course, there is an argument to be made, that the specific living space would not exist without the cooperative investment beforehand, yet it still feels ironic to restrict "affordable housing" behind being able to invest into the cooperative.
Besides only providing services to their members, many cooperative organizations of course have normal customers, for example you may receive a loan from a credit union, without being its member, so in some cases you may enjoy the benefits of cooperative organizations without first obtaining a membership.
Acting responsibly is very important in the conservation of common-pool resources and positive effects can be witnessed in fishing cooperatives. The times when a "tragedy of the commons" can be averted, are when the actors behave responsibly and try not to exploit the resource. One example of this happening is the geysers in California, as explained in Chapter 2, the appropriators chose to shut down generators in order to make sure the geysers would not be depleted, foregoing short-term gains in favor of long-term benefits.
These same long-term benefits are often prioritized and emphasized by cooperatives, the Seafood producers cooperative in Alaska uses its long tradition as advertisement, as seen on their website, while the "Bündnis Bürgerenergie" in Germany emphasized that they do not work to maximize profits, but instead provide social services.
Responsibility can also be observed when looking at the "co-ops for 2030" platform and reading through some of the pledges, so it seems that many cooperatives try to help achieve the sustainable development goals, but one thing, which becomes apparent when researching this topic is the following: Cooperatives believe in themselves to lead positive change.
When looking at German energy cooperatives, many of them have a paragraph, which will loosely mean: "we are taking the energy transition into our own hands!", they truly believe that they can and will be a force for change. The same can be seen on the co-ops for 2030 platform, not all of these make big pledges, some of them are just small cooperatives, which still believe that they should try their best: Some are pledging to create new jobs for young people or increase the opportunities for women.
One interesting discussion I had in the process of creating the experiment was that cooperative members generally don't just end up in a cooperative, they actively seek out to become members, at least this was an assumption on my part, yet reading the "vision" of many cooperatives, which are active in sectors of sustainability, it really seems that way.
This also shows how hard it would be to examine the effects of cooperatives in an experimental environment. The first difficulty would be whether participants are familiar with cooperatives, then they would have to believe in the values of their cooperative in order to represent it and lastly we would have to portray the intricacies of cooperative organizations in a game-theoretical format.

Especially communication between cooperative members would be important to allow, voting and sanctioning structures would very likely have been important to observe as well. The dimension that the day-to-day operations of a cooperative are managed by elected directors and the members only get to vote on changes during general meetings was not taken into account by the experimental design at all.
When looking at the questionnaire the participants replied to at the end of the session, another problem is also that cooperatives were not well-known among participants, less than 50% of our

participants knew of cooperatives beforehand and only two participants were actual members of a cooperative before. Examining the framing effects of cooperative becomes difficult under these circumstances and make the decision to have a third design with a definition of cooperatives essential to further examine the effects, that cooperatives may have.
During the experimental sessions we were able to gather data, which would indicate a positive effect of framing the group of participants as a cooperative, however the low number of experimental sessions leaves only a small sample size so comparing the data between our three groups will not provide conclusive evidence.
Our findings would indicate that members of a cooperative organization treat the common-pool resource more sustainable through an overall lower investment level, however one big finding was also, that the group with the highest average payout was also the group with the biggest spread between participants with a high and low payout.
General observations before and after each session also indicate that the groups never acted as a group, but instead the participants treated the sessions as competitions among them. Questions about the highest earner make that really obvious, as it would imply that participants were trying to set a new "high score", as though there were leaderboards involved. It is safe to say that this was an economic game and participants did treat it like a "game" they were playing.
When comparing the observations to those from 1994, there was some valuable insight gained: Participants today are less willing to exploit the common-pool resource than they were almost 30 years ago. The average of the original three groups was higher than the maximum investment amount of our group 3. While the original work found that the groups had averages around the Nash-equilibrium, our study shows that our groups invested very differently, without altering any of the calculations behind the experiment.
Attributing these findings to the cooperative organizations would be the wrong conclusion, as even our first group, which did not act as a cooperative, had a lower Investment: 90% of the average investment in the original three groups. So, while it was by far the group with the highest investment in our experiments, it was still acting much more sustainable than the original three groups, of which all had an average of more than 60 Tokens.
This effect may have many different causes, it could be either what was outlined in Chapter 1, that sustainability has become an important topic for the general population and especially younger people. It could also be caused by the fact that all participants were affiliated with Hochschule Darmstadt, which is very active in sustainability sciences, or it could have been many other factors, which are not measurable through our experiments. Trying to figure out why the results were so different can only be speculated at this point and would require a more large-scale study to find conclusive evidence for.
In closing, while cooperative organizations believe in themselves as a force for positive change in the world, and some of them may have a measurable positive effect on sustainability efforts, like Germany's energy cooperatives, which produce electricity using only renewable energy sources, I could not find conclusive evidence for a positive effect in a laboratory environment when playing an economic game.

12. Further research and limitations

While the presented evidence in this thesis might suggest linkages between cooperative organizations and a positive effect on handling common-pool resources, it is also not without

faults. As illustrated in chapter 4.4 and reiterated in the Conclusion, our current and new experimental data is very limited and should not be considered conclusive evidence under any circumstances. It merely serves as a basis to consider researching the effects of cooperatives on common-pool resources more detailed in the future.

To truly measure the effects a cooperative organization may have on conserving resources, it would need a new experiment, designed from the ground up only to try to measure this. The experimental design is very limited in trying to portray a cooperative organization. Our participants may have been stakeholders during the game, but they were not acting as one cooperative, they were still eight individuals, as they were trying to maximize their own personal gain. Core ideas of a cooperative were also not considered: Each member of a cooperative holds a financial stake within the organization, there are voting rights for each member and they of course also communicate.

This was only based on experimental research, which itself may have been one of the problems with this thesis: The participants are never actually part of a cooperative, neither is there any risk for their participation, meanwhile a fishing cooperative that overfishes, will also have to live with the results of their behavior. Often the stakes are much higher than simply "who received the most money in this experiment", livelihoods may be endangered by reckless behavior and the economical wellbeing of the members is always at risk. The original experiment was too abstract to truly show the effects this may have.

Examining the effects a cooperative may have on common-pool resource problems is also very difficult in real life scenarios, in the end these are common-pool resources, it is difficult to exclude appropriators and limit it to only cooperative organizations. In the one famous example of the fishing cooperatives in north rhine-westphalia, where being a member of a fishing cooperative is mandatory to fish, it took great governmental intervention to reach this point and even so there may still be some small areas, which do not yet have a true cooperative organization managing it.

Other issues may be that Germany has a lawbook dedicated to cooperatives, other countries may have different rules in place, which may make comparisons between different cooperatives more difficult, for example with the United States of America, cooperative organizations and their legal entities depend on each state. While cooperatives may identify themselves through their core values, the legal background is just as important to consider.

One possible future research topic could be how beneficial the fishing cooperatives in Germany may be in comparison to "normal" fishing companies, but the problem with that topic would also be, that there are strict rules in place globally in order to prevent overfishing of specific species, at that point the question is not anymore whether the cooperatives are beneficial for sustainability of the fish stocks, but whether they provide more economic sustainability for the individual fishers.

There are still many topics, which might be worth researching, when it comes to the effects of cooperative organizations on sustainable development, not everything can be answered through a single study and sustainable development is not a local topic, but instead a global one, so finding organizational structures, which allow sustainable development globally, would be very helpful in combating climate change.

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