Public goods games for collective agri-environmental contracts design

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Abstract

This thesis conducts a structured literature review of public goods games (PGG) experiments to analyze the differences between laboratory and field studies and to understand whether farmers cooperate more or less than standard PGG subjects. In addition, novel data on public goods games conducted on European farmers from Germany, Hungary, Netherlands, and Poland are analyzed to understand the effect of heterogeneous starting endowments on cooperation. While farmers have higher cooperation levels on average, the difference between farmers and students are not statistically significant. German and Dutch farmers have higher contribution levels than Polish and Hungarian farmers in the standard version of the game, and heterogeneous endowments decrease cooperation levels except for Polish farmers. A reduction in cooperation levels under the heterogeneous endowment treatment is also found in the laboratory literature.

Keywords: Framed field experiment, Cooperation, Collective action, Heterogeneous endowment

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Abbreviations

AECM	Agri-environment-climate measure
AES	Agri-environment scheme
CAP	Common Agricultural Policy
EAFRD	European agricultural fund for rural development
EU	European Union
MPCR	Marginal per capita return
OECD	Organization for Economic Co-operation and Development
PGG	Public goods game
PPD	Percentage Point Difference
VCM	Voluntary contributions mechanism

1. Introduction

The European Union’s Common Agricultural Policy (CAP), through the Agri-Environmental Climate Measures (AECMs), provides financial compensation to farmers for adopting practices that improve environmental sustainability. AECMs are predominately implemented at farm level on a voluntary basis. AECMs incentivize various farm management practices from which farmers can choose which they want to implement (e.g. buffer strips, organic farming, rewetting a landscape). Despite the attribution of over a quarter of the CAP’s budget to mitigate and adapt to climate change in the period 2014-2020, the effectiveness of AECMs is considered low (European Court of Auditors, 2021).

In most European countries, farmers decide individually which of the various AECM provided by member states on a regional level to choose from, without any prior coordination with surrounding farmers. Individual decisions mostly depend on local farm-level factors. However, single farms can be too small to effectively deliver ecosystem services at larger scales (Westerink et al., 2017). Collective schemes could potentially play a role in improving the effectiveness of agri-environmental policies compared to schemes that follow individual farm-level approaches (Olivieri et al., 2021). The Netherlands provides a unique example of this approach. Dutch farmers exclusively receive second pillar support from the CAP’s agri-environmental schemes under collective contracts. With collective implementation of Agri-Environmental schemes (AES), the participants can share transaction costs, risks, and knowledge. This sharing can strongly facilitate small farms to be involved in the protection schemes. Other advantages of organizing environmental management in collectives may include improved coordination of land management at larger scales, lower administrative costs (only one formal contract is needed), and greater flexibility (as farmers may set aside no land, whereas others may set aside a lot of land to reach a certain target at larger scales) (European Network for Rural Development, 2016).

Public Good Games (PGG) are commonly used in Economics to assess people's willingness to cooperate. PGG experiments can help to understand cooperation behavior under different institutional designs (Ledyard, 1995). For example, researchers can study whether cooperation behavior changes under rewarding or sanctioning institutions. In the basic version of a public goods game, each player receives an initial endowment and then decides how much to contribute to a group account, the amount contributed by all players to this group account is multiplied by a constant greater than one and smaller than the number of players and then redistributed equally to each player. The interest of the group is at odds with the interest of the individual player. The game can be a useful tool to proxy farmers' cooperation behavior, and some studies have attempted to study agricultural students' or farmers' cooperation behavior using the public goods game (Bouma et al., 2020; Rommel et al., 2023).

This study contributes to the discussion of collective contracts design and public goods games in two important ways. First, I conduct a structured literature review to expand the meta-analysis of PGGs by Zelmer (2003), by investigating the most recent literature on public goods games and – more importantly – by contrasting it with data from studies that have farmers as subjects, including novel data from the European research project *Contracts2.0*.[1] This will allow me to analyze differences between laboratory and field studies and understand if farmers are more or less likely to cooperate than standard subjects. Second, I focus on the role that heterogeneity in initial resources plays in achieving high levels of cooperation. Using novel data from public goods games with farmers in four EU member states, I will investigate whether farmers are more or less likely to cooperate under heterogeneous endowments in the public goods game.

[1] The main objective of Contracts2.0 was to develop novel contract-based approaches to incentivize farmers for the increased provision of environmental public goods along with private goods. https://www.project-contracts20.eu/

2. The public goods game literature

Economics has long been interested in understanding human cooperation. One popular tool used in experimental economics to study cooperation is the public goods game, first introduced by Glass (1976). In the standard version of a PGG, participants are grouped into sets of n players, and each player starts with an initial endowment e (usually money). They must decide how much of their endowment to allocate to a private account and how much to contribute to a group account. The individual contribution, x_i, can range from 0% to 100% of their initial endowment ($0 \leq x_i \leq e$). The contributions of all n players are then multiplied by a constant factor, a, and the total multiplied contributions are evenly distributed among all n players. The typical steps of a public goods game are illustrated in Figure 1.

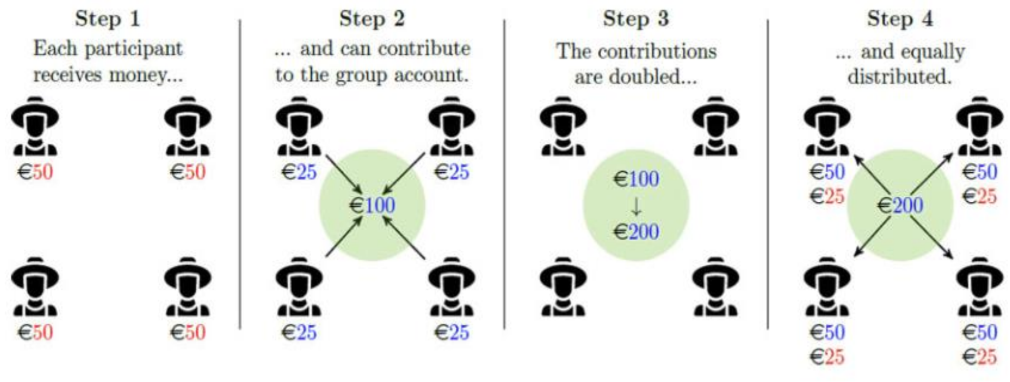

Figure 1. Schematic representation of steps in a Public Goods Game.

Source: Rommel et al. (2023)

The distribution ratio, known as the marginal per capita return (MPCR), is always positive but less than one to allow the game to be a social dilemma. To ensure this, the multiplication factor a must be $1 < a < n$. In this setup, also called voluntary contribution mechanism (VCM), each player receives the same payoff, regardless of his contribution, allowing for freeriding behavior. Under the VCM, the payoff for each subject *i* in a one-shot public goods game can be summarized using the following function:

$$\pi_i = \frac{a\left(\sum_{j \neq i}^{n-1} x_j + x_i\right)}{n} + e_i - x_i$$

Where x_j are the contribution of the $n - 1$ other players, e_i is the initial endowment of player *i*, and x_i is player *i*'s contribution to the group account (Isaac et al., 1984). The first part of the right-hand side of the equation is the payoff from the group account, while the second part denotes the part of the endowment, which is kept in the private account.

In linear public goods games, payoff maximizers under standard preferences have the dominant strategy not to contribute any tokens to a group activity (*free-riding behavior*). The standard linear voluntary contribution mechanism public goods environment is parametrized to create this social dilemma. Experimental economists have tested the theoretical prediction and factors that influence cooperation in laboratory environments (Zelmer, 2003). In an experiment, the game can be played just once, as a so-called "one-shot" PGG, or several rounds can be played in "repeated" or "dynamic" PGGs to analyze cooperation over time. Typically, cooperation levels differ between participants and decline over time. The declining pattern of contributions over time has been found to be consistent with two behavioral explanations. First, conditional cooperation (or reciprocity); i.e., many decision-makers contribute to public goods when others also contribute or are expected to do so (Fischbacher et al., 2001; Fischbacher and Gächter, 2010). Second, confusion (or decision errors); i.e., many decision-makers, particularly in laboratory experiments, are supposed to contribute to a public good not out of a preference motive or out of a reciprocity norm, but instead because they misunderstand the incentives of the game and therefore are unaware how to correctly pursue their self-interest (Andreoni, 1995; Burton-Chellew and West, 2012).

Experimental variables affecting cooperation levels in PGGs

Many factors can influence contribution levels in PGG and discussing all of them is beyond the scope of this study, but a few are relevant in the context of collective contracts. In repeated games as the number of decision sequences increases (**number of rounds** played), there is a decrease in cooperation (Lugovskyy et al., 2017; Neugebauer et al., 2009). **Communication**, especially face-to-face, has been demonstrated to increase contribution levels (Bochet et al., 2006). In addition, conformity has been shown to decrease free-riding behavior (J. P. Carpenter, 2004). **Punishmen**t in PGGs has been widely studied. It has been shown to increase cooperation (Fehr and Gächter, 2000; Xiao and Houser, 2011) but this depends on the nature, the degree, and the implementation of the punishment. For instance, privately implemented punishment reduces cooperation in relation to a baseline treatment without punishment. **Threat of expulsion** leads to a rise in contributions to nearly 100% of endowments with significantly higher efficiency compared with a no-expulsion baseline (Cinyabuguma et al., 2005). **Social nudging** (i.e. labeling contributions above a particular threshold as being "good") leads to a striking increase in the cooperation rate (Barron and Nurminen, 2020). Minimum contribution required by **obligation** cannot sustain cooperation over time (Galbiati and Vertova, 2008). As one may expect, rewards increase cooperation in social dilemma games, in particular, higher **marginal per capita return** (MPCR) leads to higher cooperation levels (Stoop et al., 2018). **Voluntary participation** can induce a recovery of cooperation levels when the payoff yielded by the exit option is high enough, so that the usually observed decay of average contribution levels can be counteracted (Boun My and Chalvignac, 2010). **Anonymity** does not affect participants' contributions (Laury et al., 1995). The "strangers vs. partners" has been extensively studied. Ghidoni et al. (2019) provide a review of these studies, underlining that if the likelihood of meeting the same partner again in the future is high, cooperation rates are high.

Previous meta-studies on public goods games

Zelmer (2003) conducted a meta-analysis of standard linear public good experiments, analyzing 27 studies (representing a total of 711 groups of participants). Data were extracted using a standardized protocol and the results were analyzed using weighted ordinary least squares, using average group efficiency as the dependent variable. The author found that the marginal per capita return, communication, constant group composition over the session ("partners"), positive framing, and the use of children as subjects had a positive and significant effect on the average level of contribution to the public good. Heterogeneous endowments to subjects, experienced participants, and soliciting subjects' beliefs regarding other participants' behavior prior to the start of the session/period had a negative and significant effect.

Besides the already mentioned study on "strangers and partners" by Ghidoni et al. (2019), more specific meta-studies found evidence for collective contracts design. Fiala & Suetens (2017) showed that transparency about individual payoffs of group members is destructive to cooperation. In contrast, transparency about choices tends to lead to an increase in contributions. Guido et al. (2019) provided meta-analytic evidence on how group formation affects cooperation in repeated PGG. The authors found no difference in terms of cooperation between studies implementing endogenous sorting (subjects are allowed to enter or exit groups on their own accord) and experiments implementing an exogenous matching of subjects into groups (e.g. by the experimenter). Finally, Eisenkopf & Kölpin (2023) showed that leading by example (the establishment of a first-moving leader) generates persistently higher and more coordinated contributions in comparison to groups without a leader.

Lab vs. field experiments

To explain the behavior observed in laboratory experiments, one basic assumption of experimental economics is that individuals behave consistently across similar game forms, both within and outside the laboratory. It could, however, be the case that subjects pick up other mechanisms such as norms about behavior in groups or broader fairness concerns that depend on context. For instance, Liberman et al., (2004) have found that naming a prisoner's dilemma "Wall Street game" vs. "community game" has a strong impact on behavior in the game. There may be differences between the cooperation rates among students in the lab and other subjects in the field, and there is ample evidence of differences in ultimatum game behavior across cultures (Henrich et al., 2001; Oosterbeek et al., 2004) and some evidence of differences in honesty across professions (Rahwan et al., 2019). For this reason, field experiments have been used.

The correlation of behavior in experiments and reported real-world behaviors has been documented by several studies. Carpenter and Seki (2011) matched conditional cooperation in public goods laboratory experiments to the team productivity of Japanese fishermen. Englmaier and Gebhardt (2016) carried out PGG experiments in the field and the laboratory with (mostly) the same subjects. They could establish that laboratory behavior is externally valid, as behavior in the lab and the field correlate. They conclude that the simple game theoretic structure of the public good game can capture important aspects of real-world cooperation.

However, Voors et al. (2012), used a sample of subsistence farmers in Sierra Leone to compare behavior in a standard PGG and the field (a real development intervention). In this study, they found no meaningful correlation in behavior across contexts. This casts doubt on the prospect of using lab experiments as "predictors" of behavior in real life.

Farmers' behavior in Public Goods Games

Because of the recent interest in collective contracts, there has been a growing focus in the literature on farmers' behavior through public goods games (Bouma et al., 2020; Rommel et al., 2023). Despite this interest, the majority of PGG experiments are still carried out in laboratory settings with students, with the assumption that they are a good proxy for the real subjects of interest. Students are usually perceived as a convenience sample and preferred over non-students for methodological reasons: ease of recruitment and cost-effectiveness. They allow experimental researchers to obtain insights at relatively low costs and with small sample sizes. Belot et al. (2015) compared the behavior of students and non-students in some classic experimental games (Trust Game, Dictator Game, Public Goods Game, Beauty-contest and Second-price Auction). They found that students are more likely to behave as selfish and rational agents than non-students.

Before Limbach et al. (2023), no studies directly compared farmers' behavior against the standard subject pool used in PGG. One study that tried to address this issue is Bouma et al. (2020). They compared the results of a threshold public goods game experiment between standard subjects (university students) and a subject pool consistent of students involved in the agricultural sector (in this study the authors argue that they are a good proxy of farmers subjects). They found that on average, group contributions seem to be higher for the non-standard subject pool, but this is only a proxy for farmers so no conclusion can be drawn.

In their recent paper, Limbach et al. (2023), transposed a laboratory experiment conducted by Le Coent et al. (2014) in a contextualized lab-in-the-field experiment with 24 French farmers. They were comparing a conditional subsidy to an unconditional subsidy (i.e., the standard subsidy in existing agri-environmental schemes). In the lab, Le Coent et al. (2014) found promising results regarding the conditional subsidy while the results found in the field by Limbach et al. (2023) show that farmers cooperate even more successfully than students in laboratory settings and sustain more efficient outcomes over time.

Endowment heterogeneity in Public Goods Games

Identifying mechanisms that affect cooperation in social dilemma games has been a challenge in the field of economics. Many factors can influence contribution levels, and different variations of the standard PGG have been used to analyze their effects. One of these factors is endowment heterogeneity (i.e., different players in a group receive a different initial endowment) since the distribution of wealth can affect the cooperation rate of individuals in PGG. This is almost always the case when considering farmers approaching collective contracts, with different farmers having different initial resources.

The literature argued on whether endowment heterogeneity has positive or negative effects on cooperation. In his early review of public good experiments, Ledyard (1995) concludes that heterogeneity tends to decrease contributions. In contrast, Chan et al. (1999) observed that heterogeneity has a positive effect on aggregate contributions but only when communication is not allowed. Most of the recent literature seems to agree with the fact that endowment heterogeneity negatively affects the level of contribution (Cherry et al., 2005; Fung and Au, 2014; Kingsley, 2016).

There are two main factors that may affect the contribution rate in PGGs with endowment heterogeneity: the origin and the asymmetry of the endowment. Regarding endowment origin, economists and psychologists have long argued that the origin of wealth influences individual behavior. Windfall wealth (i.e. unearned) can lead to more generosity and risk-taking (Cherry, 2001). However, some researchers find evidence that the origin of assets does not influence subject behavior in laboratory settings (Clark et al., 1998; Rutström and Williams, 2000). Cherry et al. (2005) found no relevant difference in contribution for different allocation methods (earned or given endowment). For this reason, the origin of wealth in this study will be omitted. The asymmetry of resource distribution and the level of inequality was studied by Fung and Au (2014). They concluded that when endowments in the group become more unequal, symmetrically heterogeneous groups cooperate less. This change in cooperation could not be found in hegemonic groups (i.e. groups where a single individual is given a higher endowment). Thus, asymmetrical wealth distribution seems to not change contribution levels and it is going to be omitted in this study.

Regarding endowment heterogeneity in farmers' studies is once more Bouma et al. (2020) that apply endowment heterogeneity to a threshold PGG. They suggest that environmental payment schemes should consider cost heterogeneity in the design of group contracts. They found that a differentiated bonus rule to solve the heterogeneity problem improves game outcomes, but only for standard subjects (university students). For agricultural students (used as a proxy for farmers), there are no significant differences between the distribution rules. For this reason, more studies on farmers are needed.

3. Data and Methods

3.1 Structured literature review

3.1.1 Searching and selection criteria

The first step was to search and download the studies used by the previously cited meta-studies on PGG. In addition, a search of the economic literature was carried out to update and expand Zelmer (2003). Results of linear public goods experiments using a voluntary contribution mechanism were identified through an online search on EconLit, ScienceDirect, and Google Scholar.

Keyword searches were conducted using the following terms: "public goods" and "experiment*",[2] "voluntary contribution" and "experiment*", "variable contribution" and "experiment*", "cooperation" and "experiment*", and "public goods game". To obtain more results relevant to the focus of this thesis, a second round of search was conducted adding the term "farm*" to the above search criteria.

Candidate studies from these bibliographic sources were included in the review if they:

- were reports of a laboratory or field experiment where observations for one or more sessions are gathered in a controlled environment;
- used a standard voluntary contribution mechanism linear public goods game;

[2] The asterisk (*) is a commonly used wildcard symbol that broadens a search by finding words that start with the same letters. That is, this search provides results with any of the following terms: experiment, experimental, experimentally, etc.

- reported group-level results (or averages over groups of similar types) for at least one of the outcomes of interest;
- could be obtained through electronic access or libraries at the Swedish University of Agricultural Science or the Catholic University of Sacred Hart and/or through the World Wide Web;

In addition, I used data from the European research project *Contracts2.0* regarding public good games of farmers in Germany, Netherlands, Poland, and Hungary.

3.1.2 Data extraction protocol and collection form

A conventional data extraction protocol was used for the validity assessment and the data collection. It included the following steps:

1. Search databases using the previously mentioned keyword search terms.
2. Review the abstract to determine whether the article is relevant.
3. Retrieve full text for those articles identified as relevant.
4. Review article in its entirety for specific information according to the *extraction form*.
5. Conduct an Internet scan or contact authors for any missing information.
6. Review citation list for relevant articles.

The data extraction form is essential for ensuring consistency in the process of data collection. It serves the important functions of providing a historical record of the provenance of the data, minimizing the need to go back to the original documents, and acting as the source of data for the following analysis (Mulrow et al., 1997). The form was developed following the Cochrane Handbook for Systematic Review (Higgins et al., 2022). The first step was to outline and define the final objective and outcome of the analysis. This helped to decide the right amount of data to collect from an individual paper (too much data can lead to a waste of time and too little may lead to unsatisfying results). The second step was to group data elements to facilitate the form development. The four identified groups were "paper information", "participant information", "study design" and "extras". The third step was to identify the optimal way of framing the data items (i.e. determining which variables to collect). Here is important to incorporate flexibility to allow for variation in how data are reported. The last step was to pilot-test the developed form to allow fine-tuning and problem detection.

The pilot testing allowed the identification of the definitive variable to be included in the dataset. Table 1 describes the variables used in the analysis. The information collected about the "paper information" were: *title*, *author names*, *year of publication*, and, to avoid potential publication bias effects, a dummy variable indicating whether or not the article was *published* in a scientific journal was included. Regarding the "participant information", dummies for the variables of interest of this study were included to capture whether the participants are *farmers* or standard subjects (*students*). In addition, a dummy to capture the location of the experiment was used. In this case, three geographic areas are identified: *Europe*, *US,* and *other location*. The "study design" information included the other variable of interest for this analysis, that is whether the study is a *laboratory* or *field* experiment, captured with a dummy variable. Moreover, the *sample size*, *group size*, *initial endowment,* and *MPCR* were recorded. All these variables are important experimental parameters that can affect cooperation levels. Another dummy was included to capture if the study is a *one-shot* or *repeated* PGG, in which case the number of repetitions (*rounds*) was also recorded. The *average group contribution*, representing the willingness to cooperate, was then recorded and used in the analysis as the dependent variable.

Table 1. Variables description and coding for the literature review

Variable Name	Description
Published	= 1 if published in a scientific journal, = 0 if not
Europe	= 1 if European subjects, = 0 if other (US or other location)
USA	= 1 if US subjects, = 0 if other (European or other location)
Lab	= 1 if laboratory study, = 0 if field study (or lab-in-the field)
Student	= 1 if student subjects, = 0 if other (farmers or other)
Farmers	= 1 if farmer subjects, = 0 if other (students or other)
Sample_size	number of subjects participating in the experiment
Group_size	number of subjects in an experimental group
Endowment	initial endowment for each participant in a group

MPCR	Marginal Per Capita Return
One_shot	= 1 if single repetition, = 0 if repeated game (multiple repetitions)
Rounds	Number of rounds of the game
Avg_contribution	0% - 100% average group contribution (as percentage of initial endowment)

3.2 Effect of heterogeneous endowment on farmer's cooperation

3.2.1 Data

Novel data from the project *Contracts2.0* regarding PGGs conducted on farmers in four European countries will be analyzed and then compared to studies in the literature. The experiments were conducted in Germany, Hungary, Netherlands, and Poland through an online survey[3]. Across the four countries, the same baseline version of the PGG was conducted, however, the overall experimental design of each survey slightly differs. The dataset for each of the four countries consists of different treatment variables. These datasets were cleaned in order to have the same variables and merged to have comparable information across countries. Table 2 provides a description of the variables included in the final dataset used for this analysis (see Appendix 1 for descriptive statistics).

Table 2. Variables description and coding for the Contracts2.0 dataset

Variable Name	**Description**
base	= 0% - 100%
heter_low	= 0% - 100%
heter_high	= 0% - 100%
NL	= 1 if from Netherlands, = 0 if from other country
DE	= 1 if from Germany, = 0 if from other country
HU	= 1 if from Hungary, = 0 if from other country
PL	= 1 if from Poland, = 0 if from other country
gender	= 1 if male, = 0 if female or other
age	= age in years
university	= 1 if university degree, = 0 if no university degree
full_time	= 1 if participant is full time farmer, = 0 if participant is part time farmer
livestock	= 1 if livestock farm, = 0 if other (mixed or crop)
crop	= 1 if crop farm, = 0 if other (mixed or livestock)
tot_land	= total holding size in hectares (owned and leased)

[3] See (Rommel, 2021) for more details on the data collection protocol.

The baseline treatment (i.e. homogeneous endowment) was played in the same way in all four countries. The heterogeneous endowment treatments, for all experiments except the Dutch, consist of giving 50% lower endowment respect the baseline to half the players and 50% higher to the other half. For the German experiment, this treatment consisted of participants receiving either EUR 25 or EUR 75 as an initial endowment (vs EUR 50 of the baseline). In Hungary, the intervention of unequal endowments required farmers to choose their contribution levels when receiving either a high (HUF 15,000) or a low (HUF 5,000) initial endowment (HUF 10,000 for the baseline). Poland farmers received either PLN 50 or 150 with a baseline endowment of 100 PLN. The Dutch experiment differs from the others since the endowment variation was ± 40% of the baseline endowment: EUR 30 for the low heterogenic endowment and EUR 70 for the high one with EUR 50 as the baseline treatment. The endowment, however, was given with the objective of having similar purchasing power in order to be as comparable as possible (Table 6 reports the average exchange rates for the year of the study).

3.2.2 Literature search

A search of the literature was conducted to retrieve papers that studied heterogeneity in the allocation of wealth in PGG. A total of 6 studies were identified, but only 4 of them had a baseline that allows for the calculation of treatment effect. All of the studies considered in this analysis have the same MPCR (0.5) except for Fung and Au (2014) where the MPCR is 0.73. Most of the studies use a symmetric wealth distribution, except for Chan et al. (1999) where they used a hegemonic distribution (one group participant receives a higher endowment than the others).

4. Results

4.1 Strucutred literature review results

The papers retrieved through the searching procedure were uploaded on Mendeley, this allowed for all the duplicates to be easily deleted. A total of 342 potential papers were obtained. Further investigation according to the inclusion criteria yielded 50 studies that were included in the analysis (see Appendix 2 for the complete list).

4.1.1 Summary statistics and graphical inspection

Table 3 shows the summary statistics for the variables employed in the structured literature review. Regarding the PGGs characteristics, as we expect the sample size varies greatly among experiments while the number of individuals in a decision group is generally 4 people. Most of the observations come from studies published in scientific journals while only the data from the projects *Contracts2.0* are unpublished,[4] representing 4% of observations. Most of the studies are conducted in the US and Europe and, as we expect, the majority (68% of observations) are conducted in laboratory settings. As for the subjects' characteristics, only 13% of observations involve farmers and 67% involve the standard subjects (students) of PGGs. The only observations included in the data about European farmers are from the project *Contracts2.0*[5]. The average contribution is around 50% of the initial

[4] With the exception of German farmers' data published by Rommel et al. (2023)

[5] Limbach et al. (2023) reports data about French farmers' contribution levels in a PGG but it's not included in the analysis due to the recent publication date.

endowment, which summarizes and represents the contribution levels found in the literature.

Table 3. Descriptive statistics for the literature review

Variable	Observations	Mean	Std. Dev.	Min	Max
Sample size	75	99.97	187.26	15	1344
Group size	75	4.53	2.44	2	16
MPCR	76	0.45	0.15	0.02	0.75
Published	76	0.96		0	1
Unpublished	76	0.04		0	1
Europe	76	0.41		0	1
USA	76	0.34		0	1
Other location	76	0.25		0	1
Lab	76	0.68		0	1
Field	76	0.32		0	1
Student	76	0.67		0	1
Farmers	76	0.13		0	1
Other subjects	76	0.20		0	1
One shot games	76	0.36		0	1
Repeated games	76	0.64		0	1
Number of rounds	76	8.09	7.47	1	30
Average contribution (% of initial endowment)	76	0.49	0.13	0.19	0.87

Source: Own calculations.

Comparing graphically the average contribution in one-shot and repeated games, at first glance, we can see that cooperation tends to be lower in repeated games compared to one-shot games (Figure 2). This is in line with the effect of decreasing cooperation over time. There seems to be no clear trend on the difference between laboratories and field studies. Regarding farmers, there seems to be a higher level of cooperation compared to non-farmers subjects, both in one-shot and repeated studies. But as with a relatively high standard deviation, represented by the error bars those differences are probably not statistically significant. Here is important to note that the non-farmers category includes both ‘students’ and ‘other subjects’. Another relevant note is that there is only one observation regarding farmers' contribution in repeated games, this makes any inferences irrelevant.

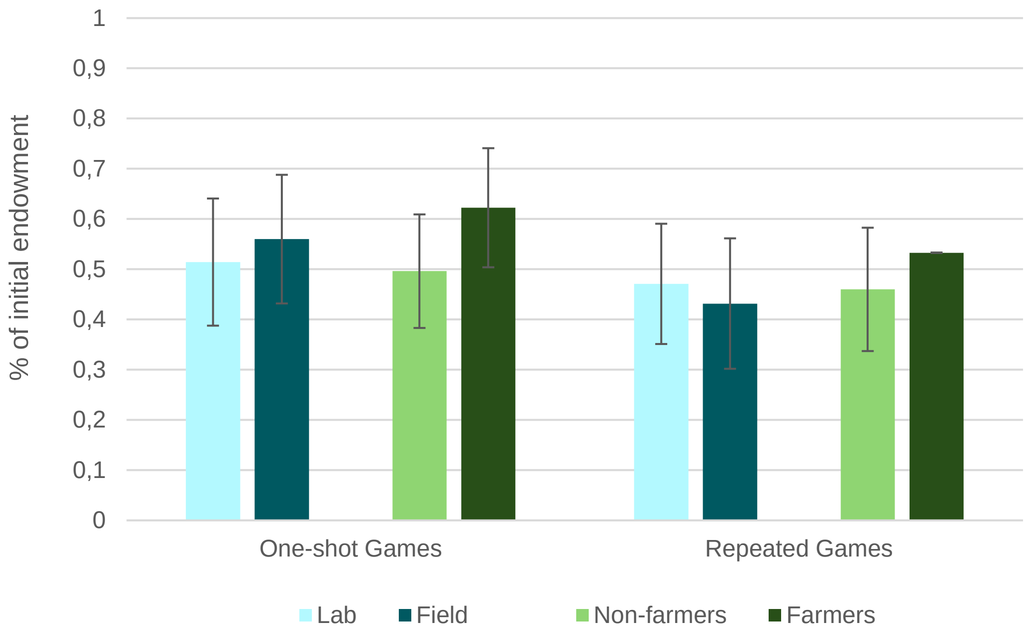

Figure 2. Average contribution in one-shot and repeated PGGs

Notes: error bars indicate the standard deviation. The Non-farmers category includes both 'students' and 'other subjects'.

Source: own calculations based on literature review

Focusing on the interest of this study, directly comparing farmers' average cooperation with standard subjects of PGGs, we can derive a similar picture (Figure 3).

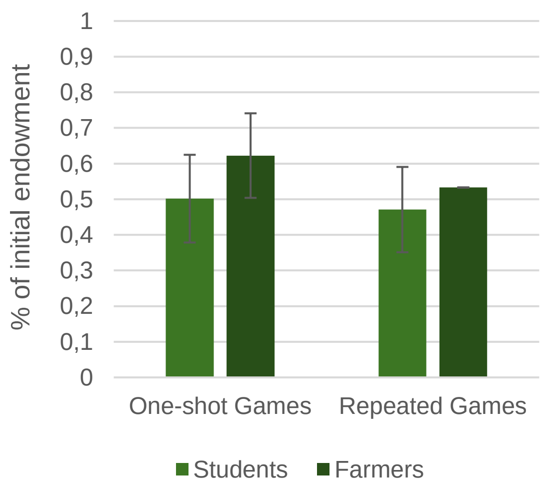

Figure 3. Average contribution students vs farmers

Notes: error bars indicate the standard deviation.

Source: own calculations based on literature review

4.1.2 Statistical analysis

The quantitative data synthesis is carried out with the statistical software Stata (StataCorp, 2019). A standard OLS regression was used to assess the effect of the different variables on contribution levels (Table 4).

Table 4. Effect on contribution levels

	Estimate	(SE)	95% confidence interval	
Published	0.03	(0.10)	-0.18	0.24
Europe	-0.02	(0.07)	-0.16	0.11
USA	-0.03	(0.06)	-0.16	0.09
Field	0.05	(0.07)	-0.09	0.19
Farmers	0.07	(0.09)	-0.11	0.25
Other subjects	-0.12	(0.10)	-0.31	0.08
One shot	0.04	(0.03)	-0.03	0.11
Group size	0.00	(0.01)	-0.01	0.02
MPCR	0.12	(0.13)	-0.14	0.39
Constant	0.46	(0.20)	0.06	0.85
Observations	75			
R-squared	0.20			
Adjusted R-squared	0.09			

The statistical analysis did not find any deviations from the null hypotheses of no impact of game design, geographical focus area, publication status, or subject pool. Subjects in Field studies contribute 5% more and subjects in laboratory settings and Farmers contribute 7% more than students on average. But, in line with the graphical analysis, these results do not provide evidence against the null hypothesis. Other experimental variables such as whether the game was one-shot or the MPCR also showed a positive effect on contribution levels but again these results are statistically non-significant. This implies that the null hypothesis cannot be rejected. Lastly, group size does not affect contribution levels.

4.2 Heterogenous endowment results

4.2.1 Analysis of farmer's data

I first analyzed the subject's behavior at the aggregate level to examine the effect of heterogenous endowment treatment. Figure 4 shows the average individual contribution under the baseline scenario and the two heterogeneous endowments for each country. We can consider the Netherlands case as a reference, where collective AESs have already been implemented. Looking at the baseline scenario (i.e. with homogeneous endowment), German farmers display similar behavior to the Dutch farmers, while Hungary and Poland show lower overall cooperation levels. Regarding contribution levels under the heterogeneous treatment, the Netherlands and Germany again display similar behavior, with individuals receiving a higher endowment contributing slightly less (as a percentage of the initial endowment) than people receiving the lower amount. Hungarian farmers, compared to the baseline, show a reduction in contribution when receiving less money while they are more generous when given the high endowment. Finally, Poland shows an increase in contribution for both low and high endowments compared to the baseline (see Appendix 3 for the distribution of individual contribution levels).

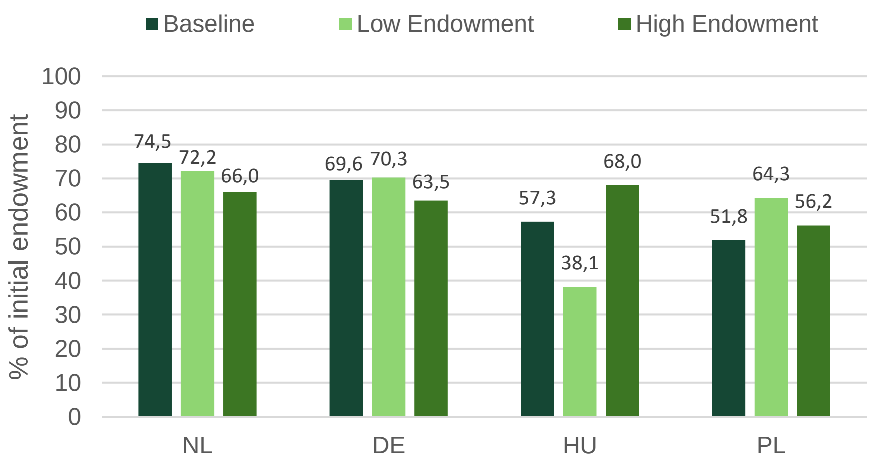

Figure 4. Average individual contribution in the four countries

Source: *Contracts2.0* data

Now carrying out an analysis of individual decisions to better understand what factors influence cooperation levels. Table 5 shows the results for each scenario (i.e. homogeneous endowment, low endowment, and high endowment).

Table 5. Regression results for contribution levels under different treatments

	Baseline		Heter_low		Heter_high	
	Estimate	(SE)	Estimate	(SE)	Estimate	(SE)
(Intercept)	72.27	(11.38)	65.29	(11.62)	50.92	(11.86)
DE	-2.48	(6.57)	-0.61	(5.73)	-0.81	(5.85)
HU	-17.86***	(6.31)	-40.10***	(5.93)	-2.87	(6.05)
PL	-21.04***	(6.30)	-8.55	(6.01)	-10.26*	(6.14)
gender	-1.07	(4.90)	-2.09	(4.58)	1.20	(4.67)
age	0.17	(0.14)	0.12	(0.13)	0.04	(0.14)
university	1.13	(3.81)	-3.44	(3.59)	7.23**	(3.66)
full_time	-7.69*	(3.97)	3.89	(3.85)	8.20**	(3.93)
livestock	-4.02	(5.80)	-3.56	(6.60)	-1.44	(6.74)
crop	-0.28	(4.95)	9.01	(5.95)	9.40	(6.07)
tot_land	0.00	(0.01)	0.00*	(0.00)	0.00	(0.00)
Observations	300		291		291	
R-squared	0.10		0.23		0.06	
Adjusted R-squared	0.06		0.20		0.03	

Significance levels: * p < 0.1; ** p < 0.05; *** p < 0.01

Notes: Netherlands is the reference category for the four countries

The statistical analysis confirms that there is no difference between Dutch and German farmers in all three scenarios. Hungarian and Polish farmers show lower cooperation rates under the homogeneous endowment treatment while under the heterogeneous endowment, only Hungarian farmers show a reduction in contribution when receiving a lower amount. Having a university degree and a being a full-time farmers seems to increase contribution levels by 7.23 and 8.20 points respectively.

4.2.2 Comparison with literature results

Table 6 shows information about the farmer's data and the literature regarding the treatment effect of heterogeneous endowments. The treatment effect is given by the Percentage Point Difference (PPD) between the baseline contribution (i.e. the average group contribution for the standard PGG with homogeneous endowments) and the heterogeneous contribution (the average group contribution under the heterogeneous endowment treatment). Figure 5 graphically summarizes the results. We can see that heterogeneous endowment generally lowers contribution levels for farmers, except for Polish farmers, where this is not the case. The reduction in cooperation is similar for standard experimental subjects. Overall, 3 out of 4 studies showed that heterogeneous endowment had a negative impact on cooperation.

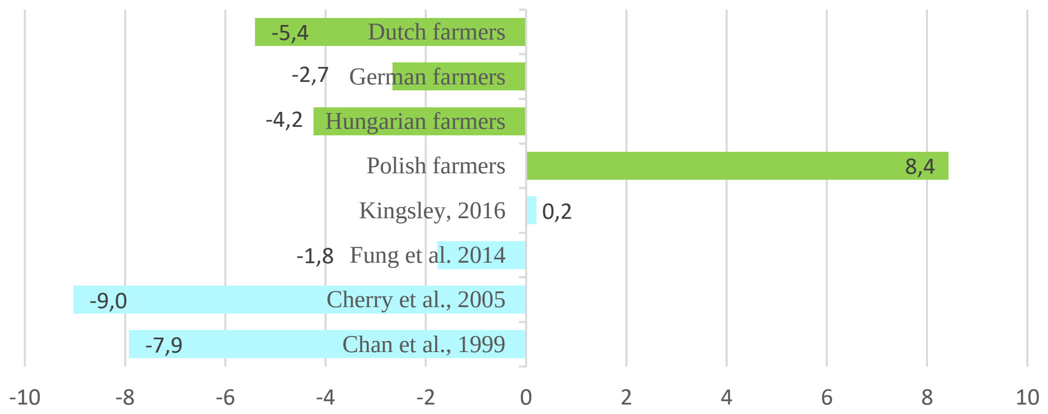

Figure 5. Percentage Point Difference of baseline and heterogeneous contributions

Notes: Contribution levels refer to the average group contribution reported as a % of the initial endowment.

Source: own calculation based on literature review and data from the project *Contracts2.0*

Table 6. Data on the heterogeneous endowment treatment effects

Source	Sample size	Group size	MPCR	Base endowment	Low endowment	High endowment	Experimental currency	Exchange rate (EUR)*	Round	Baseline contribution	Heterogeneous contribution	PPD
Chan et al., 1999	72	3	0.5	20	18	24	L$	-	20	56.27	48.4	-7.9
Cherry et al., 2005	124	4	0.5	10-40	10	40	USD	0.806	1	42.14	33.11	-9.0
Fung and Au, 2014	96	3	0.73	30	25	35	USD	0.753	10	53.50	51.73	-1.8
Keser et al., 2017	160	4	0.5	*n.d.*	10	20	ECU	0.01	25	*n.a.*	60.67	*n.a.*
Kingsley, 2016	128	4	0.5	50	40	60	L$	-	15	34.4	34.6	0.2
Nockur et al., 2021	212	4	0.5	*n.d.*	20	40	ECU	0.005	24	*n.a.*	52.8	*n.a.*
Dutch farmers	90	4	0.5	50	30	70	EUR	1	1	74.55	69.14	-5.4
German farmers	96	4	0.5	50	25	75	EUR	1	1	69.56	66.90	-2.7
Hungarian farmers	84	4	0.5	10000	5000	15000	HUF	0.003	1	57.30	53.06	-4.2
Polish farmers	96	4	0.5	100	50	150	PLN	0.219	1	51.83	60.26	8.4

Notes: Base contribution and Heterogeneous contribution refer to the average group contribution[6] reported as a % of the initial endowment. MPCR: Marginal Per Capita Return; PPD: Percentage Point Difference; L$: Laboratory dollar; ECU: Experimental Currency Unit

*average exchange rate of the year of the study, one unit of the experimental currency is equivalent to the reported number of euros.

Source: Data from the literature and the project *Contracts2.0*

[6] The data for EU farmers was collected in an online survey. Given the nature of the data, average group contribution is not available, for this reason for the heterogeneous contribution it is considered the average between the contribution under the low and the high endowment as a proxy for average group contribution.

5. Discussion

The first aim of this study was the review of the public goods game literature to identify differences between laboratory and field studies and to investigate whether farmers are more or less likely to cooperate than student participants in laboratory experiments. The results show that field studies display larger contribution levels but the estimated coefficient in the regression exhibits no statistical significance. Secondly, while the regression coefficient shows a positive impact on contributions, there is no evidence that farmers show a higher willingness to cooperate than standard PGG subjects. This is in opposition to the expectations based on previous research. While Zelmer (2003) in his meta-analysis of lab studies with standard subjects found that the cooperation level is around 37.7% of the initial endowment. Studies carried out in different parts of the world that involve only farmer subjects appear to report higher cooperation levels; Rommel et al. (2023) found that German farmers contribute about two-thirds of the initial endowment on average. Oniki et al. (2020), in a repeated PGG of Ethiopian farmers, report an average contribution level of 83% in the first round that decreases slightly in the following rounds. Tsusaka et al. (2015) found an average of 54% in the Philippines. For farmers in Costa Rica, the contribution average was 56% (Hopfensitz and Miquel-Florensa, 2017).

The fact that no statistical significance was found might be due to several limitations on the methodology employed in this analysis. Regarding the search and selection process, the keyword terms used for the literature search might have not been exhaustive, causing to miss some potentially relevant studies. Furthermore, the sample of studies is relatively small causing high variability in group-level estimates and a high risk of committing both type I and type II errors (as there is no documented effect, a type II error may be the bigger concern). Another layer of this problem is given by the fact that most economic games use monetary incentives to reduce hypothetical bias (Smith, 1976). Due to budget constraints, the experiments included generally have small samples, making the variability of results of single studies increase. Comparing several studies with different experimental designs also increases variability, since small changes in design can change the result quite drastically (Huber et al., 2023).

The second aim of this study was the analysis of the effect of heterogeneous endowment. The results show that when individuals have different starting resources, contributions are lower on average, compared to the homogeneous endowment condition. One notable exception was the Polish farmer data, where heterogeneous endowments *increased* contributions.

Analyzing the willingness to cooperate of individuals using a public good games approach also has some limitations. As already mentioned, successful collective action depends on multiple factors. Slightly different experimental design choices can influence the contribution outcomes and make it difficult to compare results from different studies. Whether a subject acts selfish or unselfish can also depend on stochastic choice, censoring those factors (Bardsley and Moffatt, 2007). The PGG experiments carried out in the project *Contracts2.0*, due to Covid-19 restrictions employed an ex-post random matching of participants and ex-post payments. The constraint of carrying out the experiment in online settings can reduce the quality of information obtained as one of the critical factors of PGGs (i.e. interaction between participants) is omitted (Sattler et al., 2022). This experimental design feature about the participant’s incentives also restricted the analysis of farmers' cooperation over time and raises questions about the use of the strategy method (i.e. players decide on a contingent action for each and every possible first player move). Although Brandts and Charness (2000) found no difference between responses to the first player’s observed action and the strategy method, in complex games, the strategy method requires that people thoroughly familiarize themselves with the ramifications of all choices, so that data obtained doesn’t derive from uninformed choices. Using a public good games approach to derive conclusions about AECMs contract design also has some limitations. One crucial consideration is the external validity, i.e., the connection between experimental game outcomes and real-world behaviors (Smith, 1976).

The direct use of the results of this thesis for policy conclusions is difficult. Public good games employed to assess farmers' cooperation on AECMs, represent abstract research scenarios, posing a challenge in translating findings into real-world applications. One may argue that a high general willingness to cooperate in a simple game might be to some extent viewed as a necessary condition for real-life cooperation, while it is by no means a sufficient condition once real-world complexities and personal relationships come into play. The choice between a one-shot and repeated public goods game also has significant implications. In this research, both one-shot and repeated games are included in the analysis. It is worth mentioning that one-shot games lack the capacity to analyze conditional cooperation; i.e. many decision-makers contribute to public goods when others also contribute or are expected to do so (Fischbacher et al., 2001; Fischbacher and Gächter, 2010). This is a relevant aspect in understanding farmers' cooperative behavior on AECMs. While repeated games are commonly used to analyze conditional cooperation, the literature suggests that contributions in repeated public goods game experiments decrease over time (Isaac et al., 1984; Ledyard, 1995).

One-shot games do not accurately reflect the decision-making process about the implementation of AECMs. European farmers, in many instances, must repeatedly decide about the implementation of collective contracts. This is why implementing a repeated PGG when studying collective contracts would be an important extension. To correctly reflect the real-world dynamics of collective AECMs, the experimental design of a PGG must also implement a threshold framework. Compared to standard linear public goods games, threshold games are fundamentally different in incentive structure as the threshold turns the game into a coordination game (Ledyard, 1995). Threshold public goods games most closely resemble the agri-environmental conservation scheme: only when the collective manages to provide a certain level (or threshold) of environmental services will the subsidy be paid. The threshold should be considered not only in terms of services provided, but the experiment design should also take into account the land area of single farms. A single big farm can provide more environmental services than several small ones. In this context, group size becomes a relevant factor to be analyzed. Analyzing cooperation levels in different countries is also crucial, given the heterogeneity among the four countries regarding cooperation. Flexibility and precise targeting for farmers in different European countries become important to adjust AECMs to farmers' local conditions.

6. Conclusions

This thesis investigated the difference in cooperation levels between farmers and student subjects in public goods games and the effect of heterogeneous endowment on farmer cooperation using data from the available literature and novel data from the European research project *Contracts2.0*, involving farmers from the Netherlands, Germany, Hungary, and Poland. The research showed that even if farmers seem to contribute more, the differences between farmers and students are not statistically significant. Moreover, differences in the initial endowment seem to lower the overall cooperation levels both for farmers and student subjects. Whether this lack of a statistically significant difference is the result of small sample sizes remains an important question for future research.

Given the heterogeneity of socioeconomic- and farm characteristics across the EU member state and regionally inside countries, future research should be carried out targeting the specific area of the contract implementation to gauge significant insight. The analysis of the willingness to cooperate of farmers should include a threshold condition and a sequential framework, with the aim to reflect the real case implementation of collective AECMs. Integrating public goods games with naturally occurring collective schemes (which are currently piloted for instance in Germany) could also be an interesting route for future research, as it would also allow the researcher to assess the predictive power of public goods games for real-world cooperation. For example, one could run experiments with farmers before and after they have joined a collective contract and compare them to a control group of farmers who have not joined a collective. This will allow to understand whether more cooperative farmers (as measured through a public goods game) are joining collectives or whether joining a collective alters cooperation behaviour. Finally, this study stresses the importance of the differences between individual farmers, so considering the heterogeneity in initial resources should also be taken into account.

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Appendix 1

Descriptive statistics Contracts2.0 data

Variable	Observations	Mean	Std. dev.	Min	Max
base	342	62.88	32.71	0	100
heter_low	328	61.07	32.76	0	100
heter_high	328	63.39	30.45	0	100
NL	670	0.26		0	1
DE	670	0.21		0	1
HU	670	0.25		0	1
PL	670	0.27		0	1
gender	667	0.79		0	1
age[7]	605	49.19	14.87	19	94
university	658	0.44		0	1
full_time	670	0.63		0	1
livestock	670	0.34		0	1
crop	670	0.52		0	1
mixed_other	670	0.14		0	1
tot_land	670	162.2	1064.1	0	17830

[7] Note that for the calculation of the age variable, 65 responses were excluded due to inaccuracies. However, these responses were retained in the dataset for all other purposes.

Appendix 2

Studies included in the structured literature review

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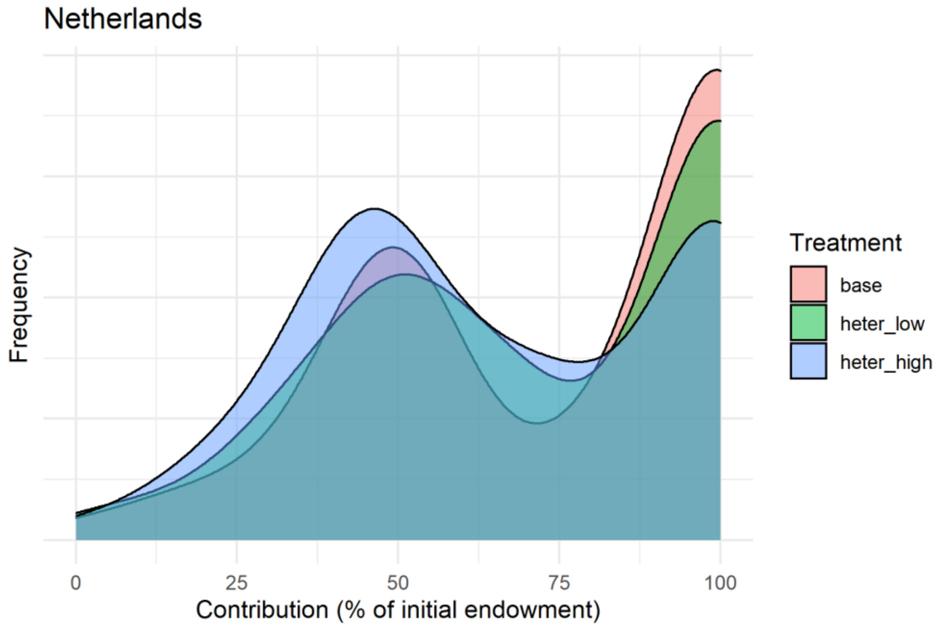
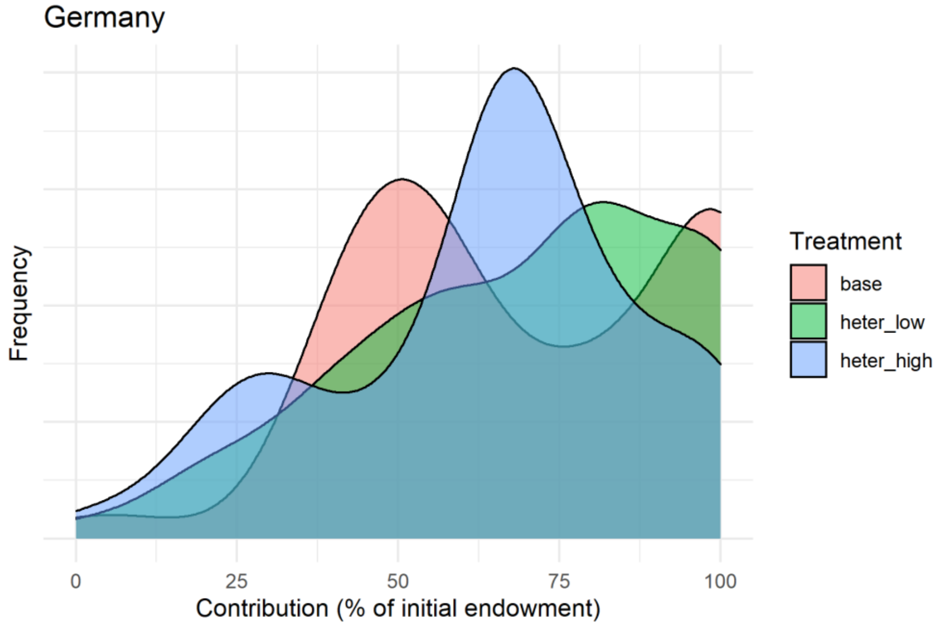
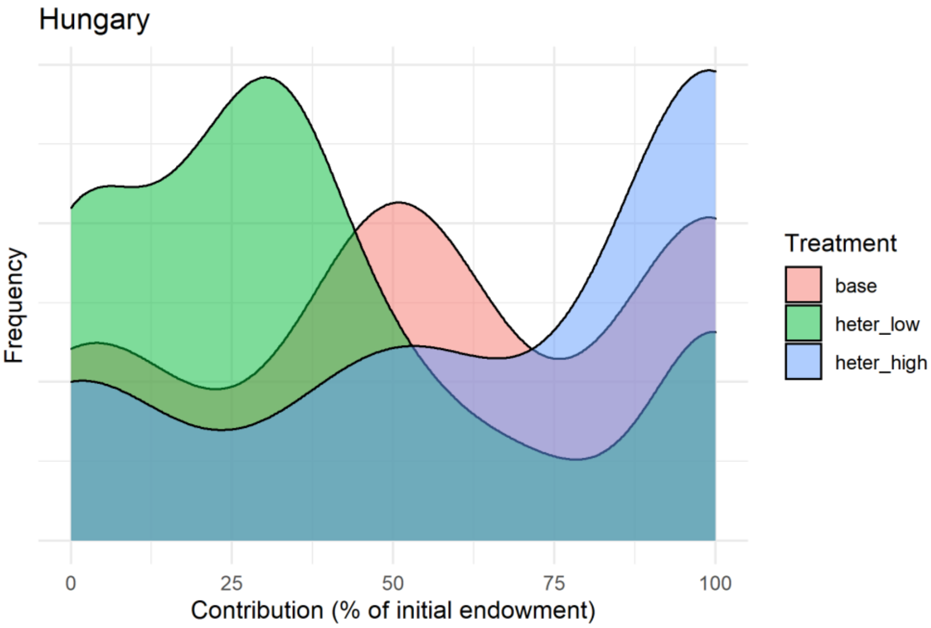
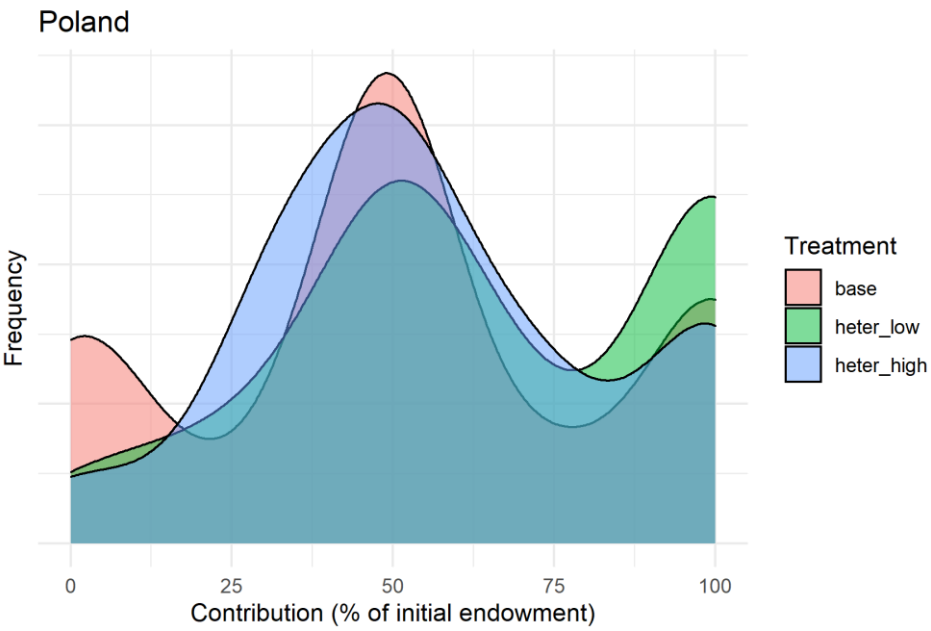
Appendix 3

Distribution of contributions levels by treatment in the four countries






Hungary
Frequency
0
25
50
75
100
Contribution (% of initial endowment)
Treatment
base
heter_low
heter_high


Poland
Frequency
0
25
50
75
100
Contribution (% of initial endowment)
Treatment
base
heter_low
heter_high

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