To what extent are Hungarian farmers willing to cooperate on agri-environmental schemes?

Experimental evidence from a public goods game.

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Abstract

European Union agri-environmental measures fail to deliver expected benefits despite playing a central role in mitigating the negative effects of agriculture on biodiversity and the environment. Implementing agri-environmental contracts following a landscape-scale rather than an individual-farm level approach could potentially contribute to improving their environmental performance. We conducted a public goods game experiment with 406 Hungarian farmers to investigate their willingness to cooperate as a pre-requisite for the successful implementation of novel agri-environmental contracts. Participants were divided into treatments to analyze how variations in three characteristics of collective contract design (namely group size, threshold, and endowment) can impact farmers' attitudes towards collaboration. The results show that unequal endowments have a large statistically significant negative effect on farmers' average contributions. Variations in group size and threshold levels have a statistically insignificant effect on contribution levels. We conclude that Hungarian farmers' propensity to cooperate is higher than expected considering their past experiences with collectivization and that strong economic heterogeneity can significantly impede their collaboration levels.

Keywords: public goods game, experimental economics, Hungary, collaboration, collective agri-environmental contracts

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Abbreviations

AECM	Agri-environmental climate measure
EU	European Union
PES	Payment for ecosystem services
PGG	Public goods game

1. Introduction

This thesis examines Hungarian farmers' willingness to cooperate on novel agri-environmental contracts using a public goods game experiment. Agri-environment-climate measures (AECMs) financially compensate European Union (EU) farmers for adopting practices addressing the detrimental effects of farming on the environment. In spite of accounting for a total expenditure of 12 billion EUR by EU Member States between 2014 and 2020[1], AECMs have so far produced insufficient or even contradictory results with regard to ecological and biodiversity quality indicators. Although some measures demonstrate positive effects on specific indicator species, the same measures show either no positive effect or a negative effect on other taxa (see Kleijn & Sutherland, 2003 for a review of the ecological evidence).

Collective agri-environmental schemes could potentially play a role in improving the effectiveness of agri-environmental policies compared to schemes that are implemented following an individual farm-level approach. In most Member States, farmers select and implement measures independently, without any prior coordination with surrounding farmers. As shown by Westerink et al. (2017) and Mckenzie et al. (2013), single farms are too small to effectively deliver ecosystem services "such as water quality and storage, wildlife conservation and the protection of cultural landscape structures" (Westerink et al., 2017, p. 177). It is thus necessary to adopt a landscape scale approach that goes beyond the individual-farm level and requires the coordination of farmers' biodiversity conservation efforts. Although the legal framework to enable a collective approach is already in place, the Netherlands remains the only EU country to strictly require farmers to organize themselves in collectives to be eligible for agri-environmental subsidies (Groeneveld et al., 2019). In addition to the research evidence that is available, the European Court of Auditors has also been advocating for a collective approach to AECMs since 2011[2].

[1] See European Commission, COM/2021/539 final: 14th Financial Report from the Commission to the European Parliament and the Council on the European Agricultural Fund for Rural Development (EAFRD) 2020 Financial Year

[2] See European Court of Auditors, Special Report No 7/2011: "Is agri-environment support well designed and managed?"

Considering this policy challenge, we are interested in studying and analyzing European farmers' willingness to cooperate on AECMs at a landscape scale. Various approaches have been employed to study farmers' adoption of environment-friendly practices. One of them is experiments using economic games, such as the dictator game, the ultimatum game, and the public goods game (PGG), which are becoming an increasingly important way of analyzing and measuring human cooperation in various contexts including agriculture. In comparison to choice experiments–which have been used to study farmers' and land managers' preferences for collective arrangements in the context of payments for ecosystem services (PES) in Europe (see for instance Šumrada et al., 2022; Villamayor-Tomas et al., 2019, 2021; Villanueva et al., 2015)– economic games such as the PGG use monetary incentives. As a result, PGG experiments enhance this literature by explicitly accounting for strategic interdependence between individual farmers in addition to relying on revealed preferences rather than stated preferences (Colen et al., 2016). Economists have conducted several field economic game experiments where they recruited farmers as participants to study a wide variety of issues related to cooperation in the agricultural sector, ranging from cooperation mechanisms (Baldassarri, 2015; Baldassarri & Grossman, 2011, 2013; Narloch et al., 2012), to social preferences among farmers (Müller & Rommel, 2018), to the effect of resource scarcity on cooperation (Nie et al., 2020; Prediger et al., 2014), to the use of economic games to promote cooperation in the field (Meyer et al., 2021). However the majority of these field experiments took place in countries that are drastically different from the context European farmers evolve in, and they do not directly address farmers' willingness to cooperate in the specific context of landscape-scale PES.

The experiment conducted by Bouma et al. (2020) constitutes a notable exception: it uses a threshold PGG to study the design of collective agri-environmental contracts in the Netherlands. Part of the participants were farm management students, thus closely resembling field subjects. Banerjee et al. (2014) also analyze spatial coordination among landowners using a laboratory experiment with students from the Pennsylvania State University. Nonetheless, generalizing the results from Bouma et al. (2020) and Banerjee et al. (2014) to all European farmers is not a pertinent approach: the Netherlands is not representative of the full spectrum of farming contexts that exist across the EU and the student participants in Banerjee et al.'s experiment could be referred to as what we call WEIRD subjects: Western, Educated, Industrialized, Rich, and Democratic, a term coined by Henrich et al. (2010).

Consequently, there is an apparent need to address this lack of literature by studying and analyzing farmers' willingness to cooperate on AECMs across various EU countries using economic games. Our approach must be inclusive of post-communist economies that became part of the EU in 2004 and which have undergone complex transitions from oftentimes collective structures (Rozelle & Swinnen, 2004). There exists very little literature using PGGs to explain cooperation in the context of post-communist countries: to my knowledge, Gerkey (2013) and Müller (2020) are the only ones to do so. Moreover, Eastern European farmers may be more reluctant to cooperate than their other European counterparts because of their experience with forced collectivization, as suggested by Fukuyama (2001) and Chloupkova et al. (2003).

This paper contributes to addressing this research gap by providing experimental evidence on Hungarian farmers' willingness to cooperate using a PGG experiment. The experiment includes five treatments that allow us to study what effects a variation in group size, an unequal endowment across players, as well as high and low thresholds have on Hungarian farmers' contribution levels to the public good with respect to the baseline version of the PGG. This experimental design provides us with an idea of how variations in those three characteristics of collective contract design (namely group size, threshold, and endowment) can impact farmers' willingness to cooperate. The results of this thesis can provide EU policymakers with elements of an ex-ante assessment: this PGG experiment with field subjects constitutes a first test of Hungarian farmers' inclination to cooperate, which is a *sine qua non* of the successful implementation of collective agri-environmental contracts.

The structure of this thesis is as follows. Section 2 describes the theory of PGGs, the treatments and hypotheses of the experiment, as well as an overview of participants' socio-economic characteristics. Section 3 provides the results of the regression analysis, followed by the discussion in Section 4 and conclusions in Section 5.

2. The public goods game experiment: theory, design, and application

2.1 The public goods game

The PGG was developed by Isaac et al. (1984) as a workhorse to study cooperation in Experimental Economics when free-riding is possible. The basic version of the game is structured as follows. Each individual in a group of n players receives an initial endowment e (most experiments use money), which they must anonymously allocate between a private and a group account. The amount of the individual contribution x_i to the public account can range anywhere between 0% and 100% of the initial endowment (thus satisfying $0 \leq x_i \leq e$). Afterward, the sum of the individual contributions to the group account is multiplied by a constant a and equally distributed among the n players, regardless of their contribution levels. This means that a player who contributed nothing will receive as much money from the group account as a player who contributed the totality of their initial endowment. If we consider a game with a multiplier factor of 2 and 4 players, a total contribution of 20,000 Forints[3] would be doubled to 40,000 Forints and divided across the 4 players for a return of 10,000 Forints per person. This means that each individual receives a private benefit of ½ for each Forint invested in the group account. This private benefit, which is equal to the ratio between the multiplier a and the group size n, is commonly referred to as the Marginal Per Capita Return (MPCR) in the public goods literature. Formally speaking, the payoff function for player i in a one-shot linear voluntary contribution mechanism PGG (Isaac et al., 1984) is the following:

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

where x_j denotes the contributions of $n - 1$ players.

[3] EUR 1 = HUF 407.35 (European Central Bank, 19 August 2022)

In our one-shot experiment the multiplier factor $a = 2$, there are $n = 4$ players, and the initial endowment e_i varies depending on the treatment group ($e_i = 5{,}000$, 10,000 or 15,000 Forints). Players end up facing a social dilemma: in a one-shot PGG with $1 < a < n$, contributing zero constitutes a unique Nash Equilibrium because only the fraction a/n (i.e. the MPRC) is internalized; while contributing everything is the social optimum, because $a > 1$.
Figure 1 shows a schematic representation of the steps of a typical PGG.

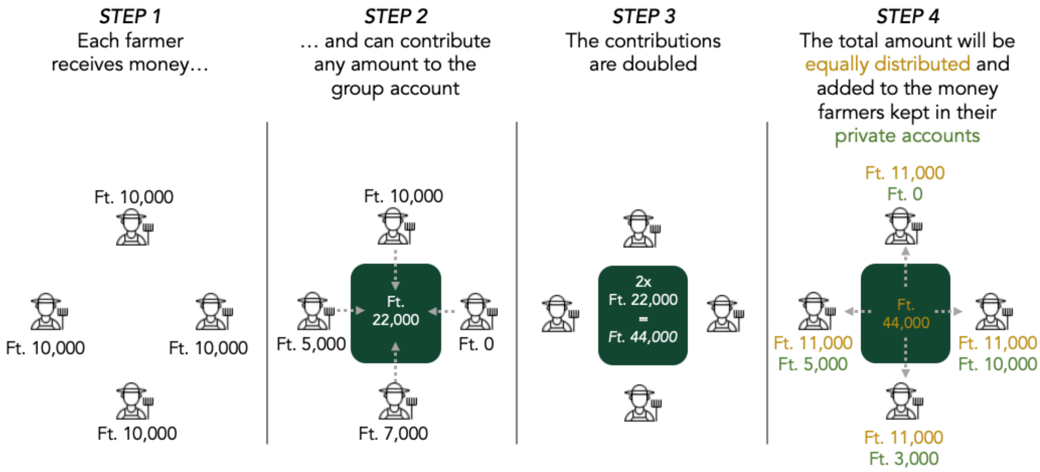

Figure 1. Schematic representation of the BASELINE version of the PGG
Ft. means Forints; graphics and text inspired from Contracts2.0 materials; PNG icon from https://toppng.com/

Early work on PGG experiments revealed that participants' behavior is less selfish than predicted by neoclassical economics: rather than playing the Nash Equilibrium, participants contribute on average between 40% and 60% of the initial endowment in one-shot PGGs (Chaudhuri, 2011).

2.2 Treatments and hypotheses

The treatments were selected based on a workshop conducted in Őrség National Park in October 2020. The workshop reunited 8 participants comprised of an agri-environmental policy expert, farmers, local food and beverage business owners, as well as a national park employee. This workshop aimed to get an understanding of various stakeholders' perspectives on collective contracts in the context of agri-environmental policy and to get them involved in the development of relevant treatments for the PGG study. The workshop discussion was framed around Őrség National Park as a common resource managed by local people which provides ecosystem services. The participants were initially presented with 9 treatments which they first discussed in pairs, and then during a plenary session. The treatments discussed were the following: group size, risky provision of the public good, rewards, sanctions, unequal endowments, leading-by-example, two different versions of a threshold public goods game, and emphasizing social norms by providing information on the large amounts contributed by other players. The final treatments to be included in the study were decided upon a majority vote wherein workshop participants could vote for 3 alternatives. The results of the vote can be seen in *Appendix 1*. In addition to the baseline version of the PGG, 4 additional treatments were selected on the basis of the vote.

The following treatments ended up being included in the study:

- **Baseline:** Four farmers must allocate 10,000 Forints between a private account and a group account. The amount on the group account is doubled and redistributed equally among all players.
- **Larger group:** Instead of four farmers, eight farmers must perform the same task as in the baseline treatment.
- **Unequal endowments:** Farmers must decide on their contribution levels according to two scenarios in which they either receive a high (15,000 Forints) or a low (5,000 Forints) initial endowment.
- **Low threshold:** Contributions to the group account are only doubled if a minimum threshold in total contributions of 10,000 Forints is achieved. (If the threshold is not reached, contributions to the group account are lost.)
- **High threshold:** Contributions to the group account are only doubled if a minimum threshold in total contributions of 25,000 Forints is achieved. (If the threshold is not reached, contributions to the group account are lost.)

Several papers have studied the impact of group size on PGG contributions. Ledyard (1995) offers a survey of the experimental literature on PGGs until the mid-1990s which suggests that group size only has a small, yet positive effect on contributions, thus going against general intuition. More experiments have been conducted since Ledyard (1995). Zelmer (2003) conducted a meta-analysis based on 27 experiments using the voluntary contribution mechanism and concluded similarly to Ledyard that group size has a small, positive, and statistically significant effect (at the 10% level) on contributions. It must be noted that Ledyard's meta-analysis mostly includes multi-period PGGs: only Goeree et al. (2002, as cited in Zelmer, 2003) and McCorkle and Watts are one-shot PGGs (as cited in Zelmer, 2003), and only approximately 7% of the used data have a variation in group size. In their study about the effect of group size in relation with MPCR variations, Nosenzo et al. (2015) also propose a brief overview of the literature, this time focused on PGGs examining the effects of group size variations *ceteris paribus*. Nosenzo et al.'s (2015) literature overview is consistent with Zelmer's findings: group size has a moderate, positive effect on overall contributions. However, the main findings of the experiment conducted by Nosenzo et al. (2015)

offer a more contrasting perspective on the role of group size in cooperation. The design of their experiment not only varies the number of players but also the MPCR from individual contributions to the public account. They observed that group size has a positive effect on contributions in the case of low MPCR, and a negative effect in the case of high MPCR. The experimental design of the present thesis has a MPCR that goes from 0.5 to 0.25 as the group size increases from 4 to 8 players. As such the MPCR of our experiment goes from medium to low–0.75 is considered a high MPCR by Nosenzo et al. (2015).

Regarding unequal endowments, Zelmer's meta-analysis (2013) finds that they have a significant negative effect on contributions at the level of 5%, assuming that participants have complete information on the endowments' unequal nature. This is also consistent with the findings from Cherry et al. (2005). Chan et al. (1996) offer some contradicting yet insightful conclusions in a study that aims to test the Bergstrom, Blume and Varian (1986) model of voluntary contributions to public goods, which predicts that unequal endowments result in an increase in contributions. In Chan et al. (1996), group behavior conforms to the model, meaning that overall contributions are higher under unequal endowments. However, the authors also highlight the fact that individual behaviors differ from the group behavior, and thus from the model: low endowment individuals overcontribute to the public good, whereas high endowment individuals under-contribute to the public good (Chan et al., 1996). Hargreaves Heap et al. (2016) support the findings of Chan et al. (1996): rich people appear to contribute less than poor people, thus pulling down overall contributions.

The threshold PGG has the potential to offer some key insights as it is a good representation of the landscape scale approach to conservation. The threshold could be interpreted as the minimum provision point of ecosystem services that farmer collectives–i.e. a critical mass of collaborating farmers–must meet in order to receive a subsidy. All in all, the threshold version of the PGG can thus be considered more "ecologically valid" than its standard version (Deutchman et al., 2022, p. 156). The effect of thresholds on contributions in a PGG is ambiguous. In his early survey of PGG experiments, Ledyard (1995) highlights the results from Isaac, Schmidtz, and Walker (1988, as cited in Ledyard, 1995) and Suleiman and Rapoport (1992, as cited in Ledyard, 1995) which both point towards a positive effect of increasing thresholds on contributions. However, in a follow-up study Suleiman and Rapoport (1993, as cited in Ledyard, 1995) do not find a significant effect of thresholds on contribution levels. Ledyard (1995) concluded that there is no definitive answer as to the effect of thresholds. Cadsby and Maynes' (1999) evidence on the impact of various threshold levels on contributions contradicts past findings. Their regression results show that in the case of a threshold PGG with no money-back guarantee, raising the threshold has a statistically significant negative impact on cooperation. In their words, given a "sufficiently high reward level, a low threshold is likely to elicit enough contributions to achieve provision [of the public good], even in the absence of a money-back guarantee" (Cadsby & Maynes, 1999, p. 67). On the other hand, there is a higher risk of contributing to public goods with high thresholds from the players' perspective, which encourages free-riding and thus results in reduced contribution levels *ceteris paribus*. Although the literature body on threshold PGGs has grown over the years, determining the effects of thresholds *ceteris paribus* based on more recent work is not an easy feat since these tend to combine thresholds with other cooperation mechanisms (e.g. punishment or common knowledge) which can lead to confoundedness (see for instance Deutchman et al., 2022; Kamijo et al., 2014).

Based on the literature, we formulate the following four hypotheses:
H1: A larger group size has a positive effect on Hungarian farmers' cooperation.
H2: Unequal endowments have a negative effect on Hungarian farmers' aggregate cooperation, and more specifically:

- **H2a:** Low endowments have a positive effect, whereas,
- **H2b:** High endowments have a negative effect on contributions to the public good, which exceeds the positive effect of low endowments.

H3: Low threshold has a positive effect on Hungarian farmers' cooperation.
H4: High threshold has a negative effect on Hungarian farmers' cooperation.

2.3 Experiment, participants' selection and characteristics

The PGG experiment was conducted between the end of August and December 2021 as part of a European research project called *Contracts2.0* (https://www.project-contracts20.eu/), one of the tasks of which is to study farmers' willingness to cooperate as a prerequisite for novel collective contracts in Germany, Poland, the Netherlands, and Hungary. Farmers were recruited in collaboration with a market research company specialized in agriculture and animal health called Kynetec (https://www.kynetec.com/). The South-West region of Hungary was in focus of the research project because of the location of the Őrség National Park: as such, the aim was to reach a target of 200 farmers originating from South-West Hungary. This target was not fully achieved, and the rest of the sample was recruited from other parts of the country. The goal was to achieve a statistical power of more than 80% to detect at least medium effect sizes (i.e. Cohen's d = 0.5) when comparing treatments: a total sample of at least 400 farmers achieved this. Farmers were recruited online at the beginning of the study, but the sample size was not large enough. As a consequence, additional surveys were conducted offline through farm visits. Farmer participants had the same questionnaire (see *Appendix 2*) regardless of whether they were recruited online or offline. In total, 519 farmers were recruited online whereas 239 farmers were recruited offline. After data cleansing, we end up analyzing a total sample of 406 farmers.

Table 1 describes and presents summary statistics for a select amount of participants' socio-economic variables, which were collected in the post-PGG survey and used in the upcoming regression analysis.

Table 1. Socio-economic characteristics of participants

Variable	Number of observations	Mean	Std. Dev.	Median	Minimum	Maximum
FEMALE	406	0.18			0	1
AGE	399	53.18	12.65	54	20	91
NO_QUALIFICATION	406	0			0	1
VOCATIONAL_SCHOOL	406	0.23			0	1
ELEMENTARY_SCHOOL	406	0.03			0	1
SECONDARY_SCHOOL	406	0.27			0	1
UNIVERSITY_DEGREE	406	0.46			0	1
OTHER_EDUCATION	406	0			0	1
AGRIC_EDUC	406	0.77			0	1
ORGANIC	406	0.03			0	1
FARMSIZE	406	100.61	11.66	100	30	300
EMPLOYEES	354	6.9	15.18	2	0	120
AECM	400	0.28			0	1

Source: own calculations

Looking at the summary statistics of the socio-economic characteristics of participants, we can see that the majority of the farmers who took part in the experiment are male.

Practically all of them have received some form of education, and about half have earned a university degree. Three-quarters of all participants received some form of agricultural education, such as an agricultural course or secondary or higher agricultural education. Only a negligible portion have a strictly organic farm, and a bit over a quarter of the participants are enrolled in some type of AECMs.

3. Results

3.1 Treatment effects

Table 2 displays the summary statistics for the contributions across all five treatments of the PGG.

Table 2. Summary on contributions as a percentage of initial endowment by treatment

Variable	Number of observations	Mean	Std. Dev.	Median	Minimum	Maximum
BASELINE	81	57.55	37.37	50	0	100
LARGER GROUP (8 farmers)	82	54.96	36.01	50	0	100
HIGH THRESHOLD	74	60.86	35.27	67.61	0	100
LOW THRESHOLD	86	64.98	33.01	50	0	100
UNEQUAL	83	45.59	30.37	40.07	0	100
UNEQUAL (HIGH)	83	38.12	33.29	33.38	0	100
UNEQUAL (LOW)	83	68	38.32	99.86	0	100
Pooled data across all treatments	406	56.76	34.91	50	0	100
Source: own calculations						

On average, we can see that participants contributed about half of their initial endowments. This is consistent with results that have been found in other experiments (Chaudhuri, 2011; Ledyard, 1995).

Figure 2 shows a raincloud plot of contributions as a percentage of the initial endowment across all five treatment groups. The plot clearly shows that the dependent variable is not normally distributed, hence justifying the use of non-parametric tests.

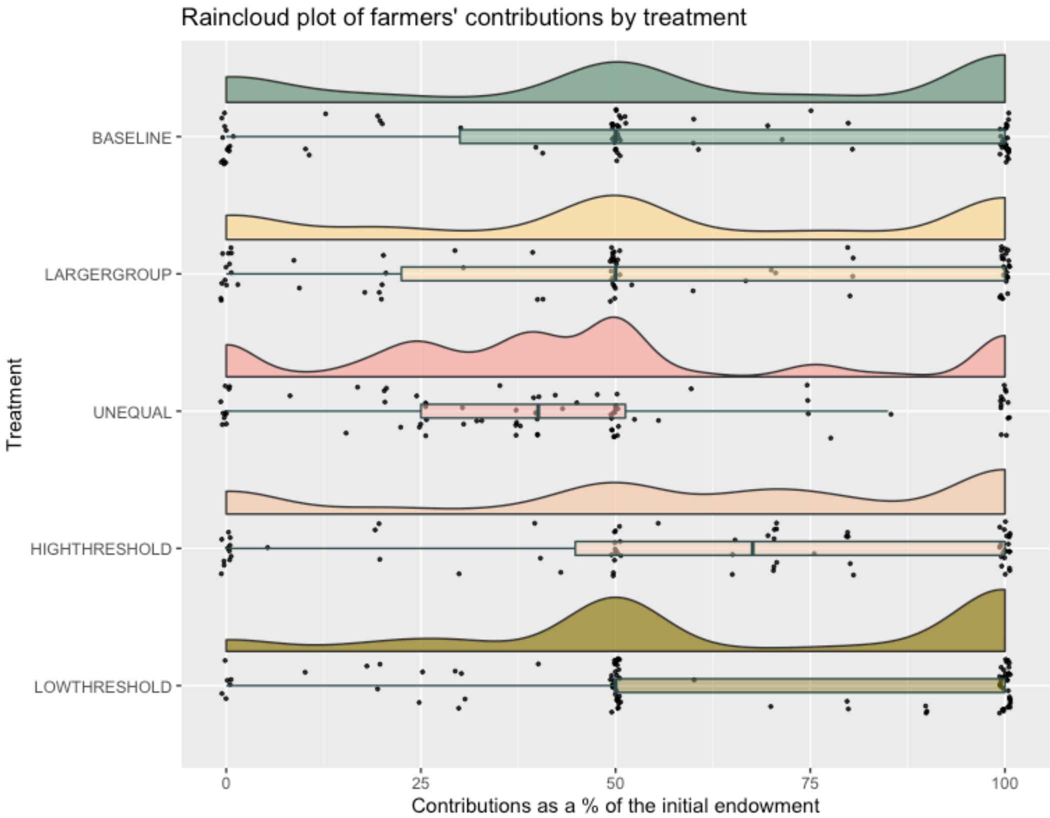

Figure 2. Raincloud plot of farmers' contributions as a percentage of the initial endowment by treatment

The Kruskal-Wallis H test shows that at least one of the treatments is statistically different at the 1% level ($\chi^2 = 16.474, \mathrm{df} = 4, \mathrm{p} = 0.002444$). In other words, this means that not all treatments perform equally from a cooperative perspective. We then use the paired samples Wilcoxon test (*Table 3*) to uncover where this significant difference stems from.

Table 3. Pairwise comparisons using Wilcoxon rank sum test with continuity correction

	BASELINE	HIGHTHRESHOLD	LARGERGROUP	LOWTHRESHOLD
HIGHTHRESHOLD	0.66731	-	-	-
LARGERGROUP	0.63220	0.44855	-	-
LOWTHRESHOLD	0.48064	0.64387	0.15099	-
UNEQUAL	0.04968	0.01098	0.15099	0.00096

Note on the p-value adjustment method: the Bonferroni p-value correction is theoretically adapted to multiple hypothesis tests, however, we decided to use Benjamini & Hochberg as Bonferroni is very conservative.

Farmers with unequal endowments contribute less (mean = 45.59, sd = 30.37) than those playing the baseline version of the PGG (mean = 57.55, sd = 37.37). This difference is statistically significant at the 5% level (Mann-Whitney U test, p =

0.04968). There is a substantial difference of 15 percentage points between the high threshold (mean = 60.86, sd = 35.27) and the unequal endowments treatments (mean = 45.59, sd = 30.37) which is statistically significant at the 5% level (Mann-Whitney U test, p = 0.01098). Finally, there is a strong significant difference between the low threshold and the unequal endowments conditions at the 1% level (Mann-Whitney U test, p = 0.00096): the contributions of farmers in the low threshold treatment are on average 20.39 percentage points above (mean = 64.98, sd = 33.01) that of farmers in the unequal endowments treatment group (mean = 45.59, sd = 30.37).

Except for the LARGER GROUP treatment, the treatment effects are consistent with the hypotheses previously formulated.

3.2 Regression results

The following regression analysis aims to investigate whether or not the differences in cooperative behaviors between the treatments fluctuate after controlling for heterogeneity across attitudes, socio-economic and farm characteristics across individual participants. A description of the variables used in the regression analysis is provided in *Appendix 3*. *Table 4* displays the output for four specifications of multilinear regressions on contributions as a percentage of the initial endowment. We use OLS for all four specifications.

Table 4. OLS regressions on farmers' contributions as a percentage of the initial endowment

	Dependent variable: **Farmers' contributions as a percentage of the initial endowment**			
	OLS1	*OLS2*	*OLS3*	*OLS4*
	(1)	(2)	(3)	(4)
Treatment effects				
LARGERGROUP	-2.594	-4.276	-1.727	-2.026
	(5.397)	(5.485)	(6.134)	(6.096)
UNEQUAL	-11.959**	-13.443**	-15.205**	-16.337***
	(5.380)	(5.471)	(6.201)	(6.173)
HIGHTHRESHOLD	3.311	0.973	2.012	1.977
	(5.540)	(5.601)	(6.326)	(6.279)
LOWTHRESHOLD	7.432	5.153	4.409	4.634
	(5.334)	(5.465)	(6.122)	(6.082)
Socio-economic variables				
FEMALE		3.147	-1.582	0.166
		(5.045)	(5.662)	(5.672)
AGE		-0.172	-0.195	-0.166
		(0.140)	(0.157)	(0.156)

ELEMENTARY_SCHOOL		-36.404	-54.870**	-61.470**
		(26.369)	(26.888)	(26.798)
VOCATIONAL_SCHOOL		-33.046	-35.488	-40.535*
		(24.659)	(24.378)	(24.324)
SECONDARY_SCHOOL		-42.555*	-43.238*	-48.197**
		(24.653)	(24.341)	(24.366)
UNIVERSITY_DEGREE		-39.312	-40.009	-44.654*
		(24.611)	(24.338)	(24.383)
AGRIC_EDUC		-1.212	-3.775	-4.042
		(4.853)	(5.581)	(5.621)
Farm characteristics, schemes enrolment and membership				
FULLTIME			5.469	5.354
			(4.335)	(4.349)
FARMSIZE			-0.387**	-0.360**
			(0.154)	(0.154)
FARM_INCOME			-0.005	-0.006
			(0.006)	(0.006)
AECM			3.547	5.253
			(4.451)	(4.466)
MEMBERSHIP			0.168	-1.521
			(4.236)	(4.264)
Attitudes				
PEOPLE_TRUST				3.794***
				(1.320)
PEOPLE_FAIR				-0.472
				(1.266)
PEOPLE_HELPFUL				-1.459
				(1.303)
NONCOOP				0.136
				(1.446)
INDIVIDUAL_WORK				-0.749
				(1.345)
Constant	57.550***	107.253***	147.054***	141.033***
	(3.828)	(26.318)	(31.215)	(32.166)
Observations	406	399	328	328
R^2	0.036	0.059	0.086	0.116
Adjusted R^2	0.026	0.032	0.039	0.056
Log Likelihood	-2,010.603	-1,970.986	-1,610.934	-1,605.344
AIC	4,033.205	3,967.973	3,257.868	3,256.689
BIC	4,057.244	4,019.829	3,326.142	3,343.928

Note: *p<0.1; **p<0.05; ***p<0.01

The first model specification simply includes dummy variables for the treatments, using the BASELINE treatment as the reference category: as such, the treatment effects in model specification 1 are exactly the same as the average treatment effects we computed in Table 2. The second model specification builds on the first model by adding socio-economic variables about participants' gender and age as well as several dummies for education. The third specification extends the second specification by including continuous and binary variables related to farm characteristics, farmers' enrolment in AECMs, and their membership in any type of organization (for example a cooperative bank, a women's group, or a producer organization). See *Appendix 2* for an exhaustive list of the types of organizations that were considered as part of the post-PGG survey. The fourth model includes variables about personal attitudes that could be related to their propensity to contribute to the public account: unlike the third model which only adds in objective farm characteristics, we can consider that the attitude variables included in the fourth specification are subjective.

It must be noted that the sample size diminishes as we progress towards the full model (specification 4). This can be explained by the fact that the questionnaire allowed participants to answer "Do not know", "Do not want to say", or "Not applicable" to questions related to variables such as DIRECTPAYMENTS, FARM_INCOME, and EMPLOYEES which account for 55, 69, and 52 missing values respectively.

Overall, controlling for heterogeneity in socio-economic and farm characteristics in addition to attitudes results in small to moderate negative variations in the treatment effects across all four model specifications. Based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) statistics, it appears that the AIC favors specification (4) over specification (3). On the other hand, the BIC favors specification (3) over specification (4). This can be due to the fact that AIC penalizes model complexity less, and thus tends to select more complex models over simpler ones. Going forward, we will refer to the estimates in the fourth model only. The reason for this is that the fourth specification includes the PEOPLE_TRUST variable which is strongly significant: selecting the fourth model hence reduces the risk of omitted-variable bias. Furthermore, UNEQUAL becomes more significant in the fourth model.

UNEQUAL is the only treatment to have a significant effect in this experiment: it has a large negative effect on farmers' contributions at the 1% significance level. Farmers in the UNEQUAL treatment group contributed on average 16.34 percentage points less with respect to farmers who played the BASELINE version of the PGG. Regardless of the model specification, the remaining treatment effects (LARGER GROUP, HIGH THRESHOLD, and LOW THRESHOLD) reveal to be insignificant. Our analysis shows that doubling the group size to 8 participants results in a 2.03 percentage points decrease in the average contributions with respect to the BASELINE version. We found that HIGH THRESHOLD and LOW

THRESHOLD result in a 1.98 and 4.63 percentage points increase in average contributions with respect to the BASELINE treatment respectively.

Given the fact that contributions to the public account are bounded by 0% and 100% of the initial endowment from below and from above respectively (meaning that contributions cannot be either less than 0% of the initial endowment or more than 100% of the initial endowment), a Tobit regression approach is theoretically more appropriate than OLS for our analysis in order to restrict the range of the predicted values (see for instance Kent, 2020; Lotito et al., 2013; Paciotti et al., 2011; Pfattheicher et al., 2017; van Miltenburg et al., 2014). We initially planned to use both Tobit and OLS, using OLS as a benchmark: the regression results can be found in *Appendix 4* for comparing the estimates. However, based on predictions of the fitted values that we computed for all four specifications under both OLS and Tobit, it clearly appears that the Tobit regressions lead to values that are well outside of the censored range (see *Appendix 5* for summary statistics of the predictions). Inversely, the OLS specifications (2), (3) and (4) only resulted in 3 out of range predictions altogether, which is why we decided to only refer to OLS in this Results section.

A Breusch-Pagan test was also conducted to test for heteroskedasticity: we found out that the error terms in model specifications (1) and (2) are homoscedastic at the 10% and 5% significance level respectively whereas the error terms in specifications (3) and (4) are homoscedastic at the 1% significance level.

4. Discussion

The results of this PGG experiment reveal that Hungarian farmers are willing to cooperate to a greater extent than expected. We found that farmers in the sample contributed on average 56.76% of their initial endowment to the group account: this figure is well within the average found in lab experiments which is between 40% and 60% of the initial endowment (Chaudhuri, 2011; Ledyard, 1995). Our results are in line with the findings from a PGG field experiment conducted by Müller in Tajikistan–another country that experienced forced collectivization of agriculture–where they found that farmers contributed 54.1% of their initial endowment to a collective machinery investment.

The literature about the role of social capital in human cooperation typically predicts low levels of cooperation in contexts exposed to totalitarian regimes. In Fukuyama's (2001, p. 7) words, social capital can be defined as an "instantiated informal norm that promotes co-operation between two or more individuals" and it constitutes a necessary condition for individuals to spontaneously and effectively work together. Chloupkova et al. (2003) and Fukuyama (2001) suggest that communism resulted in the destruction of social capital among individuals. The state favored top-down, highly centralized decisions at the cost of more horizontal forms of cooperation between individuals: people got used to following orders imposed by the state. The consequence of such heavy state intervention is a lack of trust among individuals and the absence of civil society (Chloupkova et al., 2003; Fukuyama, 2001). Gerkey's (2013) PGG experiment with salmon fishers and reindeer herders in Kamchatka, Russia further highlights the importance of not oversimplifying cooperation patterns across countries that went through a similar political history. Contributions in the experiment conducted in Kamchatka were higher than in any other place in the world. Gerkey (2013) explains that this is due to the importance of cooperation in the daily lives of Kamchatka fishers and herders, who are characterized by high economic interdependence due to the fact that they depend on the management of an uncertain common natural good. While we shouldn't be overly pessimistic about Hungarian farmers' willingness to cooperate, contribution levels in Hungary do not reach that of Western EU countries. For example, the preliminary results of the *Contracts2.0* PGG experiment conducted in Germany show that German farmers contributed on average 2/3 of their initial endowment to the group account (Rommel et al., 2021).

Going more into the specifics of our PGG results, we found a large and statistically significant negative effect of unequal endowments on average contributions. This effect size is consistent with the findings from Zelmer's (2003) meta-analysis, in which she found that unequal endowments resulted in a 14.51% decrease in contributions at the 10% significance level. We thus succeed to provide evidence for our hypothesis 2. In our experiment, increasing the group size leads to a mild positive effect. While Zelmer (2003) reports a small increase in contributions with group size, Nosenzo et al. (2015) found a negative effect of group size. Pereda et al. (2019) explain that this inconsistency stems from the fact that the effect of group size depends on specific properties such as the relationship between the full benefits of cooperation and group size: for example if in a given experiment the benefits of full cooperation increase as a function of group size, then larger groups are more likely to cooperate. Based on the mixed nature of the literature on group size effects, we neither validate nor invalidate hypothesis 1. With the exception of the *Contracts2.0* milestone report on the German experiment, there is a paucity of literature comparing the effects of a low vs. high threshold point on contributions. Cadsby and Maynes (1999) found that a higher threshold results in a 0.01% decrease in average contributions in the absence of a money-back guarantee. However comparing our results to these findings reveals to be complicated as Cadsby and Maynes (1999) expressed their results as a fraction of threshold levels, rather than as a fraction of the initial endowment. The pattern of farmers' contributions in the Contracts2.0 PGG experiment that took place in Germany is similar to the one in Hungary: a low threshold results in higher contributions than a high threshold (Rommel et al., 2021).

Except for the UNEQUAL treatment, we report statistically insignificant effects for the other treatments (i.e., LARGER GROUP, HIGH THRESHOLD, and LOW THRESHOLD). A possible explanation for our insignificant regression results would be the age structure of our sample. Despite being normally distributed, the age of the farmers who participated in the experiment does not follow the overall age structure of farm managers in Hungary. According to data from the European Commission[4], we know that less than 35-year-olds, between 35 and 54-year-olds, and above 55-year-olds make up 6%, 35.9%, and 58.1% of farm managers in Hungary respectively. In contrast, 7.77%, 44.1%, and 48.12% of our participants were less than 35-year-olds, between 35 and 54-year-olds, and above 55-year-olds respectively. Moreover, 30.7% of farm holders in Hungary are female[5] yet they only make up 18% of our sample. This means that we under-sampled older farmers and female farmers. Another explanation could be the fact that as a result of the small number of stakeholders (i.e. eight participants) who participated in the co-

[4] See European Commission, Agriculture Statistical Factsheet for Hungary (2021)
[5] Ibid

designing workshop, the treatments selected for the experiment could potentially be an inaccurate representation of collective contract aspects that are most relevant to Hungarian farmers.

Our findings have implications for the formulation and implementation of collective agri-environmental contracts in Hungary. Cardenas (2000) and Roßner and Zikos (2018) conducted field experiments in Colombia and Uzbekistan respectively: they found that in both cases, economic heterogeneity negatively impacts the likeliness of cooperation in self-governed common-pool resources. Economic heterogeneity can be measured by comparing land holding size or household income (Kahkönen, 1992 as cited in Roßner & Zikos, 2018). This could be interpreted by AECM policymakers as the fact that matching together farmers with heterogeneous farm incomes and/or farm holding sizes might impede cooperation. Moreover, in the context of landscape-scale AECMs, it can be speculated that farmers from the same area are aware of each other's economic stance. Although LOW THRESHOLD is statistically insignificant, it has a moderate positive effect on contributions that could still be relevant to policymaking. The results suggest that farmers are more willing to cooperate when faced with attainable environmental thresholds in comparison to goals that are harder-to-reach, which provides support to Pe'er et al.'s idea that agri-environmental targets should be SMART (i.e. Specific, Measurable, Ambitious, Realistic, and Time-bound) (2020).

Landscape-scale coordination is not a panacea. Besides individual contracts, multiple factors impede the environmental effectiveness of AECMs (see Kuhfuss et al., 2015 for an overview of the shortcomings of AECMs). Moreover, coordination also involves risks and costs that are beyond contractual features such as transaction costs and constraints on individual decision-making, which can discourage farmers from participating in collective approaches (Villamayor-Tomas et al., 2019).

A limitation of this experiment is that it is a one-shot PGG. The initial plan was for the experiment to include multiple rounds of the PGG, but this was prevented by the Covid-19 pandemic restrictions which were in place at the time of the data collection (Sattler et al., 2022). In practice, we would expect farmers who decide to participate in a collective agri-environmental contract to sustain their cooperation over a certain amount of time in order to maximize the provision of environmental services. For example in the current architecture of the CAP, farmers must commit to adopting agri-environmental measures for a minimum of five years. Our experimental design thus disregards the dynamic aspects of repeated interactions between farmers, although the literature says that repeated PGG experiments result in a decrease in contributions over time (Chaudhuri, 2011; Ledyard, 1995).

One might argue that the abstract nature of our PGG experiment limits the applicability of our results to the specific context of AECMs. Nevertheless, the simplicity of our experimental design allows us to isolate the effect of the collective contract design characteristics of interest (namely group size, threshold, and endowment) without risking confoundedness with any additional framing. Furthermore, it is important to recall that the results are *de facto* relevant to collective agri-environmental contracts since the treatments were selected on the basis of a framed co-designing workshop and the participants are field subjects.

Again, this simple PGG experiment constitutes a first step in understanding Hungarian farmers' willingness to cooperate on collective agri-environmental contracts. This effort will have to be completed by further research.

5. Conclusion

In this study, we analyzed Hungarian farmers' willingness to cooperate on collective agri-environmental contracts using a public goods game experiment. 406 farmers were divided into treatments in order to study the impact of specific contract design characteristics (namely group size, low and high thresholds, and unequal endowments) on their contributions to the public good. Our analysis shows that Hungarian farmers contribute more than expected considering their past experiences with collectivization, although less than farmers in Western EU countries. The large statistically significant negative effect of the unequal endowments treatment suggests that strong economic heterogeneity between farmers participating in the same collective contract could undermine the provision of environmental services. It is possible that average contributions would vary if farmers were to participate in a PGG repeated over multiple rounds.

As Covid-19 restrictions are relaxing, future research efforts could aim towards involving more participants in similar co-designing workshops as well as implementing a PGG experiment with multiple rounds. Borrowing the words of Rodríguez de Francisco et al. (2013, p. 1217), "[payment for environmental services] schemes are (…) not neutral initiatives imposed upon black canvases". Collective AECMs thus must be crafted in a careful way that takes into account the needs of policy beneficiaries. Our PGG experiment could be complemented by choice experiments to better understand Hungarian farmers' preferences for and willingness to accept collective agri-environmental contracts. Gerkey (2013) also mentioned the necessity for future research to attempt to classify individual cooperation strategies. Data on farmers' expectations in addition to their contributions is necessary to understand if they can be classified as true free riders, altruists, or conditional cooperators. Categorizing the latter as selfish would be a simplification.

This experiment contributes to the PGG literature by involving relevant stakeholders in the design of the treatments and by using field subjects instead of student subjects.

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Appendix 1

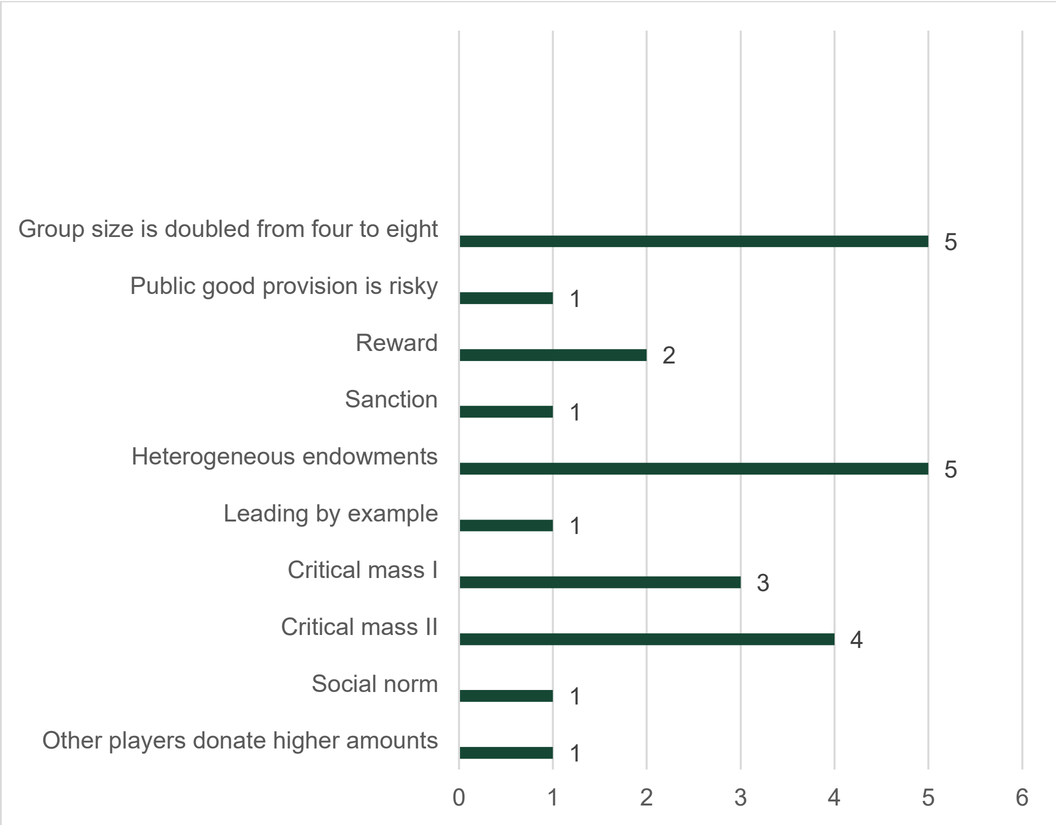

Figure A1. Results of majority vote for the selection of treatments in the Hungarian co-designing workshop (Source: Contracts2.0)

Appendix 2

The questionnaire for the public goods game experiment can be found at the following link:

https://www.dropbox.com/s/q8lr8b72276sc2b/Questionaire%20PGG%20Hungary%20-%20Contracts2.0.pdf?dl=0

Disclaimer: This questionnaire is not my own. The credits go to the Contracts2.0 research project (https://www.project-contracts20.eu/).

Appendix 3

Table A3. Description of the variables included in the regression analysis

Variable Name	Description
BASELINE*	= 1 if participant played the BASELINE version of the PGG
LARGERGROUP	= 1 if participant played the LARGERGROUP version of the PGG
UNEQUAL	= 1 if participant played the UNEQUAL version of the PGG
HIGHTHRESHOLD	= 1 if participant played the HIGHTHRESHOLD version of the PGG
LOWTHRESHOLD	= 1 if participant played the LOWTHRESHOLD version of the PGG
FEMALE	= 1 if participant is female, = 0 if participant is other
AGE	= age in years
NO_QUALIFICATION*	= 1 if participant doesn't have any educational qualification (completed less than 8 grades)
ELEMENTARY_SCHOOL	= 1 if participant's highest level of education if elementary school
VOCATIONAL_SCHOOL	= 1 if participant's highest level of education is vocation school (without graduation)
SECONDARY_SCHOOL	= 1 if participant's highest level of education is secondary school (graduated)
UNIVERSITY_DEGREE	= 1 if participant graduated with a university degree (MA or BA)
AGRIC_EDUC	= 1 if participant has any kind of agricultural education (golden spica farmer, secondary level agricultural education, MA or BA in agriculture)
FULLTIME	= 1 if participant is a full-time farmer
FARMSIZE	= farm land holding size in hectares
FARM_INCOME**	= total annual income of the participant's farm holding in 2020, in millions of forints
AECM	= 1 if the participant participates in an agri-environmental climate measure
MEMBERSHIP	= 1 if the participant is an active member in any type of organization***
PEOPLE_TRUST	= on a scale (0 to 10) to what extent does the participant think that most people can be trusted (0 = you can't be too careful, 10 = most people can be trusted)

PEOPLE_FAIR	= on a scale (0 to 10) to what extent does the participant think that most people would try to be fair (0 = most people would try to take advantage of me, 10 = most people would try to be fair)
PEOPLE_HELPFUL	= on a scale (0 to 10) to what extent does the participant think that most people try to be helpful (0 = people mostly look out for themselves, 10 = people mostly try to be helpful)
NON_COOP	= on a scale (1 to 7) to what extent does the participant disagree that cooperatives have an important role in agriculture (1 = I strongly agree that cooperatives have an important role in agriculture, 7 = I strongly disagree that cooperatives have an important role in agriculture)
INDIVIDUAL_WORK	= on a scale (1 to 7) to what extent does the participant disagree that farmers should work individually (1 = I strongly agree that farmers should work individually, 7 = I strongly disagree that farmers should work individually)

** Reference categories excluded from the regression.*

*** Total annual income were indicated in ranges in the questionnaire. The income variable was thus computed by taking the average of the lower and upper bound of each farm income range. The highest range was "Over 1.601 billion Forints". The average maximum income in Hungary is lower than our highest range, as such I assumed 2 billion Forints as the upper boundary.*

**** See Appendix 1, question "In which organizations are you a member" for a full list of the types of organizations taken into consideration.*

Appendix 4

Table A4. Tobit and OLS regressions on farmers' contributions as a percentage of the initial endowment

	Dependent variable:							
	Farmers' contributions as a percentage of the initial endowment							
	OLS1	*Tobit1*	*OLS2*	*Tobit2*	*OLS3*	*Tobit3*	*OLS4*	*Tobit4*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment effects								
LARGERGROUP	-2.594	-4.660	-4.276	-6.788	-1.727	-3.392	-2.026	-3.820
	(5.397)	(7.515)	(5.485)	(7.584)	(6.134)	(8.059)	(6.096)	(7.944)
UNEQUAL	-11.959**	-17.668**	-13.443**	-19.877***	-15.205**	-21.279***	-16.337***	-22.655***
	(5.380)	(7.438)	(5.471)	(7.517)	(6.201)	(8.095)	(6.173)	(7.995)
HIGHTHRESHOLD	3.311	2.556	0.973	-0.563	2.012	1.412	1.977	1.335
	(5.540)	(7.741)	(5.601)	(7.771)	(6.326)	(8.336)	(6.279)	(8.205)
LOWTHRESHOLD	7.432	9.364	5.153	5.775	4.409	4.570	4.634	4.994

	(5.334)	(7.507)	(5.465)	(7.625)	(6.122)	(8.089)	(6.082)	(7.981)
Socio-economic variables								
FEMALE			3.147	3.219	-1.582	-3.438	0.166	-1.172
			(5.045)	(6.936)	(5.662)	(7.349)	(5.672)	(7.302)
AGE			-0.172	-0.189	-0.195	-0.174	-0.166	-0.137
			(0.140)	(0.194)	(0.157)	(0.206)	(0.156)	(0.203)
ELEMENTARY_SCHOOL			-36.404	-47.809	-54.870**	-73.154*	-61.470**	-79.977**
			(26.369)	(40.539)	(26.888)	(38.567)	(26.798)	(37.949)
VOCATIONAL_SCHOOL			-33.046	-50.973	-35.488	-52.559	-40.535*	-57.330
			(24.659)	(38.208)	(24.378)	(35.627)	(24.324)	(35.036)
SECONDARY_SCHOOL			-42.555*	-61.986	-43.238*	-61.007*	-48.197**	-66.164*
			(24.653)	(38.249)	(24.341)	(35.663)	(24.366)	(35.188)
UNIVERSITY_DEGREE			-39.312	-57.760	-40.009	-57.331	-44.654*	-61.499*
			(24.611)	(38.209)	(24.338)	(35.724)	(24.383)	(35.233)
AGRIC_EDUC			-1.212	-0.085	-3.775	-3.033	-4.042	-3.690
			(4.853)	(6.687)	(5.581)	(7.303)	(5.621)	(7.290)
Farm characteristics, schemes enrolment and membership								
FULLTIME					5.469	6.841	5.354	6.338
					(4.335)	(5.682)	(4.349)	(5.662)
FARMSIZE					-0.387**	-0.454**	-0.360**	-0.424**

					(0.154)	(0.196)	(0.154)	(0.194)
FARM_INCOME					-0.005	-0.006	-0.006	-0.006
					(0.006)	(0.007)	(0.006)	(0.008)
AECM					3.547	5.703	5.253	7.771
					(4.451)	(5.859)	(4.466)	(5.843)
MEMBERSHIP					0.168	1.285	-1.521	-0.729
					(4.236)	(5.569)	(4.264)	(5.558)
Attitudes								
PEOPLE_TRUST							3.794***	4.717***
							(1.320)	(1.709)
PEOPLE_FAIR							-0.472	-0.792
							(1.266)	(1.634)
PEOPLE_HELPFUL							-1.459	-2.007
							(1.303)	(1.711)
NONCOOP							0.136	0.303
							(1.446)	(1.889)
INDIVIDUAL_WORK							-0.749	-1.219
							(1.345)	(1.742)
Constant	57.550***	66.922***	107.253***	135.516***	147.054***	175.956***	141.033***	170.675***
	(3.828)	(5.390)	(26.318)	(40.157)	(31.215)	(43.525)	(32.166)	(44.352)
Observations	406	406	399	399	328	328	328	328

R^2	0.036		0.059		0.086		0.116	
Adjusted R^2	0.026		0.032		0.039		0.056	
Log Likelihood	-2,010.603	-1,618.541	-1,970.986	-1,586.676	-1,610.934	-1,334.548	-1,605.344	-1,329.988
AIC	4,033.205	3,249.081	3,967.973	3,199.351	3,257.868	2,705.095	3,256.689	2,705.977
BIC	4,057.244	3,273.119	4,019.829	3,251.208	3,326.142	2,773.37	3,343.928	2,793.216
Note:								$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Appendix 5

Table A5. Summary statistics of the predicted contributions for each model specification

	Min.	Mean	Max.	No. predictions below 0%	No. predictions above 100%
OLS (1)	45.59	56.76	64.98	0	0
Tobit (1)	49.25	64.82	76.29		
OLS (2)	37.28	56.90	101.36	0	1
Tobit (2)	39.59	64.90	130.44		
OLS (3)	-11.76	55.29	98.01	1	0
Tobit (3)	-13.97	61.79	123.46		
OLS (4)	-9.886	55.286	95.878	1	0
Tobit (4)	-11.77	61.72	121.33		

Note: The number of predictions outside of the [0,100] range are only computed for the OLS specifications.

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