European Economic Review 159 (2023) 104561

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/eer

Asymmetric heterogeneities and the role of transfers in a public goods experiment

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ARTICLE INFO

JEL Classification:
H4
C92
C72

Keywords:
Public goods game
Heterogeneity
Transfers
Inequality
Cooperation

ABSTRACT

Previous experimental research has shown that cooperation is especially challenging in situations involving heterogeneous actors. Here, we investigate the effect of allowing unconditional transfers in a public goods game when actors differ asymmetrically in their endowments and productivity levels. Under this setup, full efficiency, in terms of highest maximum group payoff, can only be achieved with the full transfer of resources from the players with high endowment and low productivity to the players with high productivity but low endowment. We show that, in this setting, the availability of transfers enhances public good provision and cooperation. The voluntary transfer serves as a powerful cooperative signal, leading to high contribution rates among the recipients. However, if the transfer possibility is given but not used, cooperation erodes.

1. Introduction

When there are incentives to free-ride, cooperation in social dilemma situations can be challenging to achieve. Research inside and outside the laboratory has focused intensively on discerning the factors that hamper or foster cooperation. A central finding is that cooperation tends to be more difficult when agents are heterogeneous. For example, Cherry et al. (2005) compare groups with homogenous income to groups with heterogeneous income, finding significantly lower cooperation rates in the latter. Fisher et al. (1995) show similar results for inequality in returns from the public good, as do de Oliveira et al. (2015) for inequality in social preferences. Previous research has also highlighted that measures designed to foster cooperation tend to work differently and are often less successful in heterogeneous groups than in homogenous groups (see Nikiforakis et al. (2012), Reuben and Riedl (2013), and Kölle (2015) for punishment; Levati et al. (2007) for leadership; and Hackett et al. (1994) and Chan et al. (1999) for communication). Cooperation can be achieved in homogenous groups if group members agree, implicitly or explicitly, on a common fairness principle or contribution norm (Fehr and Fischbacher, 2004; Koessler et al., 2021). In heterogeneous groups, however, such an agreement is harder to achieve because each group member may prefer a different norm and may interpret fairness in a self-serving way (Kesternich et al., 2014; Kingsley, 2016). Thus, a contribution norm perceived to be fair in a homogenous group is not necessarily agreed upon in a heterogeneous group.

Groups and societies outside the laboratory are rarely homogenous and are often characterized by heterogeneities in multiple dimensions. However, most experimental research to date considers homogenous groups or focuses on heterogeneity in only one

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https://doi.org/10.1016/j.euroecorev.2023.104561
Received 27 January 2021; Received in revised form 20 July 2023; Accepted 7 August 2023
Available online 8 August 2023

aspect. This is a severe limitation, as multiple dimensions of heterogeneity can have reinforcing or mitigating effects on cooperation (Kölle et al., 2016; Hauser et al., 2019).[1]

This paper presents results from an experiment using a public goods game where players differ asymmetrically in their endowments and productivity levels. Individuals with higher endowments have a lower productivity than individuals with lower endowments. In situations characterized by such an asymmetric heterogeneity, efficiency gains can be realized through an ex-ante redistribution of endowment by a central authority or, in the absence of an authority with redistribution powers, by voluntary transfers among the actors. The voluntary transfers may additionally serve as a signaling tool for cooperation and reciprocity, similar to the effect of a leader who contributes first (Güth et al., 2007). To empirically assess how a transfer option affects behavior, we introduce a transfer stage to the game. This stage occurs before the contribution decisions take place and allows the higher-endowed individuals with lower productivity to transfer (some of) their endowment to the lower-endowed individuals with higher productivity.

Situations in which agents differ in their endowment or productivity are ubiquitous and, in many cases, two heterogeneities coincide in an asymmetric way. Imagine a generic case of members of a team working on a common project. Each team member has different amounts of resources that (s)he can invest in the project (e.g., time, money, or equipment), and at the same time, each member has different productivity levels for a given unit of resource invested. Up to a certain point, transferring resources to the team member with the highest productivity implies efficiency improvements. Other examples can be found in areas such as climate change mitigation. Marginal abatement costs are frequently smaller for some individuals, firms, or countries. For example, developing countries can have lower abatement costs compared to developed countries, whereas the latter may have more available resources to invest in abatement (OECD, 2009). The forest partnership between Norway and Brazil can serve as an illustrative example. Deforestation and forest degradation of the Amazon accounted for approximately 5% of global emissions in 2004 (Boucher et al., 2013). In 2008, Norway promised to pay up to 1 billion USD to Brazil's Amazon Fund, which is owned and managed by Brazilian bodies, conditional on reductions in deforestation rates. Additionally, the Memorandum of Understanding foresaw "contributions from Norway to the Amazon Fund by means of possible initial donations for 2008 and 2009″.[2] In fact, Norway made an upfront payment of 100 million NOK in 2007 and 600 million NOK in 2008.[3] Brazil achieved an impressive reduction in deforestation over the following years: while an estimated area of 12,911 km^2 was cut in 2008, only 6947 km^2 were lost in 2017, with even lower losses in between. Honoring its pledge, Norway paid a total of around 900 million USD into the Amazon Fund until 2018 (Ministry of Climate and Environment, 2018). In contrast to most other bilateral funding commitments, trust played a central role in the Norway-Brazil Agreement. Norway made advanced payments and had no direct supervision or involvement in the Amazon Fund's governance. This success story ended with a change in the Brazilian government in 2019 and a subsequent significant reduction of efforts to uphold environmental protection laws. Consequently, Norway suspended donations (Norway's International Climate and Forest Initiative, 2020).

Transfers of resources between actors may thus have the potential to uncover substantial efficiency gains in common interests, such as the mitigation of greenhouse gases. However, when there are incentives to free-ride, it is far from certain that recipients will use the transfers as intended. Monitoring and punishment are often not possible, which may prevent the occurrence of transfers in the first place.

This paper aims to provide novel insights in this regard. Employing an abstract decision setting in an economic experiment, we investigate the effects of introducing transfer possibilities on individual behavior and overall public good provision. Examining this connection experimentally allows for a clean comparison of behavior with and without transfer possibility. Specifically, we are interested in (i) whether individuals make use of the transfer possibility, (ii) how the existence and realization of the transfer affect the cooperative behavior of recipients compared to a baseline where no transfers are possible, and (iii) whether the transfer possibility increases the overall public good size compared to the baseline. With the help of a second treatment, in which the transfers were implemented exogenously, we can disentangle the effect of an intentional, voluntary transfer from the pure redistribution effect. The results show that the possibility of voluntary transfers indeed increases the size of the public good. Most subjects with high endowment and low productivity transfer their full endowment to the players with low endowment but high productivity, and these players reciprocate with high cooperation rates. However, if the transfer possibility is not taken advantage of, cooperation rates are lower than in baseline. The comparison with the exogenous treatment reveals that the redistribution of resources alone does not drive the increase in cooperation rates but that the deliberate decision to transfer is required for high cooperation rates, underlining the vital role of intention-based reciprocity.

[1] Both studies are discussed in detail in the literature section. In short, Kölle et al. (2016) show theoretically that in case of heterogeneity in abilities, introducing complementarily ex-ante heterogeneity in wealth can lead to an increase in welfare. Hauser et al. (2019) use experiments and simulations to compare how cooperation rates vary among different combinations of endowment and productivity heterogeneity.

[2] The Memorandum is available at https://www.regjeringen.no/contentassets/2ecbe3693ac04a85bf4d8ddb5d78d858/mou_norway_brazil.16.09.08.pdf (accessed 09.05.2023)

[3] One Norwegian krone (NOK) is approximately 0.1 USD.

2. Literature

Research that shares our interest in multiple, particularly asymmetric heterogeneities in public good settings is the paper by Hauser et al. (2019). In this study, the authors consider reciprocity among unequal individuals on the basis of evolutionary simulations and experimental data from an online two-player public goods game.[4] Five settings are compared: (1) full equality, (2) endowment inequality, (3) productivity inequality, (4) symmetric inequality with the more productive player also having a higher endowment, and (5) asymmetric inequality with the more productive player having a lower endowment. Their results show that when players are equally productive but their endowments differ (2), relative contributions are significantly lower than in the standard situation with full equality (1). When the productivity of players differs, no statistically significant difference is found between the setting with productivity inequality (3) and symmetric inequality (4). When, however, endowment and productivity differ asymmetrically (5), relative contributions are the lowest overall. Players with high endowment but low productivity drive this result; their relative contributions are significantly lower than under full equality (1) and symmetric inequality (4). In summary, situations involving asymmetric inequality in endowment and productivity pose a particular challenge for cooperation.

In a theoretical paper, Kölle et al. (2016) show that in groups where individuals are inequality averse and differ in their productivity, introducing ex-ante symmetric inequality in wealth can lead to an increase in welfare.[5] The higher ex-ante wealth induces the high-productivity individuals to contribute more, from which the low-wealth-low-productivity individuals benefit, leading to ex-post equality. This finding hints at the potential that transfers may have in our setting, transforming asymmetric inequality into a symmetric inequality situation and thus inducing cooperation.

Moving to general insights on heterogeneities in public good games, there are four different ways in which heterogeneity can be implemented in *productivity*: (1) changes in the marginal per capita return (MPCR) of selected individuals (e.g., Croson and Marks, 2001; Nikiforakis et al., 2012; Reuben and Riedl, 2009, 2013), (2) changes in the price for the private good for selected individuals (e.g., Fisher et al., 1995), (3) different MPCRs for contributions from selected individuals for *all* group members (e.g., Tan, 2008; Noussair and Tan, 2011), and (4) multiplication of the contributions of selected individuals with a factor larger than 1 (henceforth called the productivity parameter) (e.g., Kölle, 2015; Hauser et al., 2019).[6] While the two former and the two latter approaches are theoretically equivalent, they differ in certain practical ways. For example, all approaches reduce the individual costs of contribution for the more productive individuals, but the latter additionally include a positive externality of a player's contribution to all group members. Increasing the contribution level of the highly productive type increases payoffs for all group members. This distinction does not play a role with standard preferences, but it does in the case of social preferences. This difference, however, has not received much attention in the literature.[7] Empirically, most papers find a negligible effect of (singular) heterogeneity in productivity on average contributions (Fisher et al., 1995; Hauser et al., 2019).

While there is only a limited literature on productivity, many papers have investigated the effects of endowment heterogeneity. Substantial asymmetries in endowments mostly have a negative effect on contributions to the public good. Higher-endowed players give less in relative terms than lower-endowed players (Zelmer, 2003; Cherry et al., 2005; Buckley and Croson, 2006; Hargreaves Heap et al., 2016). However, a handful of studies also find no change in contribution levels (Hofmeyr et al., 2007; Levati et al., 2007) or even an increase among the higher-endowed players (van Dijk and Wilke, 1994). Fung and Au (2014) show experimentally that the negative effect of endowment inequality on cooperation is mediated by its skewness distribution. With increasing inequality, the decrease in cooperation rates is less severe in groups with a highly skewed distribution (one high-endowed individual and two low-endowed individuals) compared to a more symmetric setup (one high-, one medium-, and one low-endowed individual). The authors argue that the self-efficacy of the high-endowed individual increases with the skewness of the distribution, which in turn motivates higher contributions by the high-endowed individual. Synthesizing the insights from previous studies, heterogeneity in endowments seems to generally hinder cooperation.

To the best of our knowledge, no paper has tested the effect of unconditional ex-ante transfers (i.e., transfers from one player to another before contribution decisions are made) within groups in a public goods setting. Blanco et al. (2018) studied a scenario in which outsiders, who benefit from the public good but cannot contribute to it, can make ex-ante transfers to insiders who benefit from and can contribute to the public good. They find that such transfers do not significantly increase cooperation rates compared to a baseline without transfers. With the possibility of transfers, insiders condition their contributions mainly on the received transfer and no longer on their co-players' contributions, but each token transferred elicits only around 1/3 tokens of contribution. A potential

[4] In their experiment, the public goods game was repeated for at least 20 rounds. After that, the game continued with a probability of 50%.

[5] Kölle et al.'s (2016) finding that introducing symmetry into the inequalities can be beneficial differs here from that of Hauser et al. (2019), who found no significant difference in average contributions between the case of singular inequality in productivity and symmetric inequality. The research approach and specifications in both studies differed. Future research may want to investigate what caused this difference in results. Important for our study is the challenge asymmetric inequalities pose for cooperation.

[6] In the standard public goods game, the productivity parameter is 1 and usually not reported.

[7] Fellner et al. (2011), for example, introduced different productivity parameters but compared their results to those of Fisher et al. (1995), who focused on differences in MPCRs. A study by Kölle (2015) explicitly tested the differences between different productivity parameters and different MPCRs, with making the more productive player preferential (i.e., the effective MPCR of the more productive player is larger than one). Thus, the dominant strategy of the preferential player is to contribute fully to the public good. Kölle found that heterogeneous MPCRs have no effect on voluntary contributions and even a detrimental effect when punishment is possible. Heterogeneous productivity parameters, in contrast, had a positive and stabilizing effect on contributions, both with and without punishment.

Table 1
Overview of treatments.

Treatment	Endowment	Productivity	Transfer	Number of groups
Baseline	$e_A > e_B$	$p_A < p_B$	No	40
Transfer	$e_A > e_B$	$p_A < p_B$	Yes	40
Exogenous	$e_A - t \lesseqgtr e_B + t$	$p_A < p_B$	Exogenous	39 [25]

Note: 12 – 30 subjects participated in each session with a fixed group size of three subjects, resulting in a total of 357 subjects.
[25] In Exogenous one group less was conducted, due to lower show up in one session. This means that for one group in Transfer no counter group exists in Exogenous. Given that the main results presented in the following do not differ regardless of whether we include or exclude this group, we present the results on the basis of the full dataset.

reason for this feeble response lies in the fact that transfers were given to the entire group of insiders (i.e., they were split equally). This constellation may have impeded the development of a stronger reciprocal relationship between transfer senders and recipients compared to the case of a one-to-one transfer.

The remaining literature focuses primarily on (enforceable) contracts, conditional on a pre-specified strategy or contribution level (e.g., Andreoni and Varian, 1999; Charness et al., 2007; Kimbrough and Sheremeta, 2013) or post-play side payments (e.g., Bruttel and Güth, 2018; Bruttel et al., 2022; Chatziathanasiou et al., 2021, 2022[8]) in different game settings. A common finding is that side payments are frequently used. Possible explanations for this are that subjects use side payments to express their cooperative intentions or to offset payoff inequalities. Side payments can induce stable cooperation if they move the cooperation equilibrium to the interior of the Nash Equilibria region. But even if they fail to do so, cooperation rates are often still higher when side payments are offered. This suggests that side payments generally have the potential to help players coordinate on cooperation.

Lastly, the sequential order in the transfer treatment in our experiment also has some similarities to public goods games with leadership, which suggests that the leader's decisions positively impact the other players' consequent decisions (e.g., Güth et al., 2007). Contributions tend to be higher when one group member, the leader, contributes first, compared to a baseline with simultaneous contributions. Levati et al. (2007) confirm a positive effect of leadership on contributions in groups with endowment heterogeneity if the distribution of endowment is known.

3. Experimental design and procedures

Our experiment is based on a repeated public goods game where players are asymmetrically heterogeneous in endowment and productivity. Three treatment conditions are implemented: a baseline, a transfer treatment, and a treatment with an exogenous transfer. The details are outlined in the following sections.

During the experiment, we used neutral language and took great care to avoid framing effects. The experiment instructions that we handed to the participants can be found in the online appendix.[9]

3.1. The game

We utilize a linear public goods game with groups of three players. One player receives a high endowment of $e_A = 30$ tokens (*type-A player*) and two players receive a low endowment of $e_B = 15$ tokens (*type-B players*). All players simultaneously decide how much of their endowment they want to invest in the public good. Contributions by type-B players c_B are more productive than contributions by type-A players, denoted with c_A. This heterogeneity in productivity is implemented by doubling their investment in the public good. The productivity parameter, with which investments into the public good are multiplied, is $p_A = 1$ for type-A players and $p_B = 2$ for type-B players. This reduces the cost of contributing to the public good for type-B players and increases everyone's payoff from the public good. The MPCR a is fixed at 0.4 for all players.[10]

Payoffs are given by

$$\pi_A = e_A - \sum_{j=1}^{2} t_j - c_A + a\left(p_A c_A + p_B \sum_{j=1}^{2} c_{Bj}\right)$$

and

$$\pi_{Bj} = e_B + t_j - c_{Bj} + a\left(p_A c_A + p_B \sum_{j=1}^{2} c_{Bj}\right).$$

[8] Chatziathanasiou et al. study redistributive transfers in a polit-economic context—in their *battle of the sexes* game, high-ranked players can send post-play transfers to low-ranked players to "reward" their compliance with an established hierarchical order. Thus, redistributive transfers can, via indirect reciprocity, be used as a means to avoid wealth-consuming disputes (in future interactions).
[9] https://osf.io/9n7d3/?view_only=208c2ea1e96c42b795ea0df507e294d9
[10] In short, contributions by type A-players have a multiplier of 1.2 and contributions by type-B players a multiplier of 2.4.

The transfer payments are denoted by $t_j \in \{0,15,30\}$ and we elaborate on these transfers in detail in the next section. The subindex j identifies the two type-B players. At the end of each round, players are informed about all contributions and payoffs in their group.

3.2. Experimental treatments

The treatment variations are implemented by an antecedent transfer stage, which takes place in some treatments before the contribution decision. Three treatment conditions exist: *Baseline, Transfer,* and *Exogenous.* Table 1 provides an overview.

Baseline is the above-described game without an antecedent transfer stage and transfer options, i.e. $t_j = 0, \forall j$. In the treatment condition *Transfer,* type-A players can decide before play whether they want to make a transfer. Specifically, they are given the following six options: (1) no transfer, (2) transfer of 30 tokens to the first type-B player, (3) transfer of 30 tokens to the second type-B player, (4) 15 tokens to each type-B player, (5) 15 tokens to the first type-B player, or (6) 15 tokens to the second type-B player. Thus, the available options encompass the purely selfish and the socially optimal decision (zero and full transfer) as well as a middle ground, in which type-A players retain half of their endowment. After the transfer decision is made by type-A players, type-B players are informed of the choice of type-A players (i.e., the realized transfers).

Due to the resource re-allocation and differences in productivity of the two player types, the maximum amount of possible public good provision changes between *Baseline* and *Transfer*. To account for this, we implemented the additional treatment condition *Exogeneous.* Here the transfer patterns in *Transfer* are exogenously imposed. Each group in *Transfer* has a counter group in *Exog*eneous where the same transfers per round are implemented exogenously. Subjects in *Exogeneous* are informed about everyone's round endowment at the beginning of each round, but subjects are unaware that their endowment may have been modified due to an exogenous transfer. With these three treatment conditions, it is possible to isolate the effect of transfers from the effect of increased potential gains from the public good.

3.3. Implementation of the game in the experiment

The experiment consists of 10 consecutive rounds. The total payoff in the game is the sum of all the rounds' payoffs. The data presented in the manuscript come from sessions conducted using the partner-matching protocol (i.e., groups were fixed and players were identified by an ID), where matching groups remained the same across all ten rounds of the game. Thus, a build-up of reputation was possible. To test the importance of reputational effects in transfer decisions, we ran additional sessions using the stranger-matching protocol (details can be found in the online appendix).

3.4. Procedures and participants

For the experimental sessions, we used the software z-Tree (Fischbacher, 2007) and the online recruiting software hroot (Bock et al., 2014). Upon entering the laboratory, each participant was randomly assigned a seat and, accordingly, their role in the experiment. They then answered a short questionnaire to elicit risk, trust, and inequality preferences. Afterwards, instructions were handed out and read aloud to ensure common knowledge. Only after the subjects had answered all control questions and no queries remained was the experiment allowed to begin. After the game, a short questionnaire was administered, and subjects were paid according to their earnings in the game. A typical session lasted one hour, and subjects earned, on average, 17 euros. The exchange rate was 1 token to 0.05 EUR.

The experimental data were collected in two waves. In the first wave, which took place from November 2019 to January 2020, 186 observations were collected at the experimental laboratory of the University of Magdeburg.[11] During the second wave, in September 2022, an additional 171 observations were collected at the experimental laboratory of the University of Hamburg. All regression models include fixed effects for the second data collection.[12]

In total, our data encompasses 353 observations. Table A1 in the appendix provides an overview of subjects' characteristics by treatment. Participants are, on average, 25.2 years old, and 66% are female.

4. Behavioral predictions

Under the assumption that subjects are fully rational and only interested in maximizing their own monetary payoff, the dominant strategy for each player—and thus the subgame perfect Nash equilibrium—is zero contributions in all treatments, meaning no transfers will be made. Thus, the asymmetric setup and possibility of transfers do not alter the standard prediction for public goods games of zero contributions.

Of course, abundant evidence by now has shown that human behavior is influenced by more than purely monetary preferences. Contributions to public goods are commonly positive (Chaudhuri, 2011), motivated by cooperation norms and conditional cooperation (Fischbacher et al., 2001). Moreover, in heterogenous settings, a considerable number of cooperative acts are found, particularly when

[11] The supplementary data gleaned from the sessions conducted using the stranger-matching protocol were also collected during the first wave. The respective analysis is presented in the online appendix.

[12] The pre-registration of the experiment can be found here: https://osf.io/ts29r/?view_only=6c12b5b41ada4b898bd5a79d45985f76. Please note that the presented work deviates from the original study plan, a second data collection took place, and the hypotheses have changed.

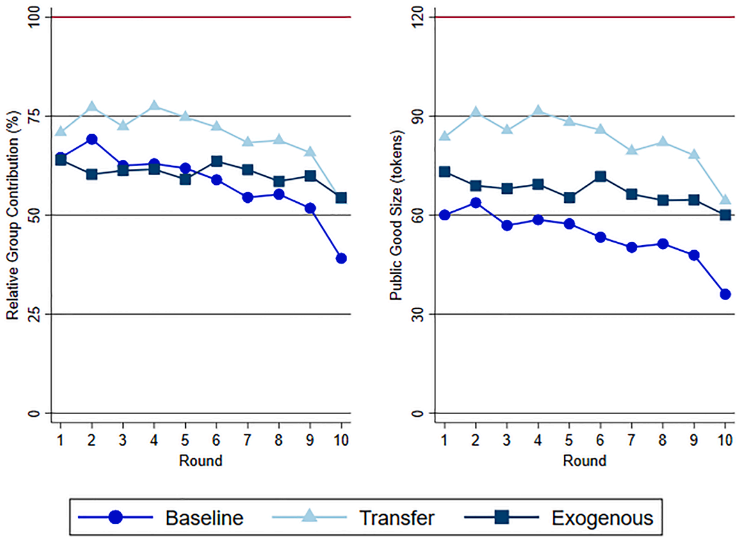

Fig. 1. Average relative group contribution and public good size over time by treatment. The left panel shows the average group contribution in percentage, averaged over groups and measured as contributions relative to endowments. The right panel shows the average public good size in tokens, measured as contributed tokens multiplied by the respective productivity factor and averaged over groups.

the inequality stems from productvity or symmetric heterogeneity in productiivity and endowment (Fisher et al., 1995; Hauser et al., 2019). People's dislike for inequality motivates redistributional actions (Kölle et al., 2016; Bolton and Ockenfels, 2000).

In our experiment, players face an asymmetric heterogeneity in productivity and endowment. Players have the option to (i) transform the setting into one with symmetric heterogeneity where previous research has shown cooperation can be more easily established and (ii) obtain substantial efficiency gains in the case of cooperation. However, to materialize the efficiency gains and potentially reach the social optimum, the higher-endowed type-A players need to trust and transfer their (entire) endowment, while the type-B players need to reciprocate the trusting action by contributing (all) available funds.

Inequality aversion and the outlook of efficiency gains can motivate type-A players to realize a transfer. The transfer dynamic thereby resembles features of a trust game (Berg et al., 1995; McCabe et al., 1998), where one player (sender) is given the opportunity to transfer any part of her/his endowment to a second player (receiver), which is then multiplied by a factor > 1, after which the receiving player can decide if and on how much to return from this amount.[13] Experimental work shows that senders commonly make a transfer and receivers return in response significant parts of the transfer. Berg et al. (1995) state that the following conditions are necessary for a trust relationship to evolve: (1) The trustor takes a risk when trusting the trustee. (2) The trustee's decision benefits the trustor at a cost to the trustee. (3) Both players are better off with this transaction compared to a situation without the initial trusting action of the trustor. (4) The trustor must believe that the trustee will interpret her action as a trusting one and that (s)he will reciprocate accordingly, otherwise the trustor will not take the risk of the trusting action. And (5) the trustee must indeed interpret the trustor's play as a trusting action, otherwise the trustee will not be willing to give up some part of her profit to reciprocate (McCabe et al., 2003).

In our *Transfer* treatment, the three prerequisites for a trust relationship are met. Substantial efficiency gains can be achieved to the benefit of both players with transfers and corresponding contributions to the public good game. Nevertheless, the unconditional transfer bears a substantial risk for type-A players and is thus likely interpreted by the type-B players as a trusting action. Building on empirical and theoretical evidence of the role of reciprocity in behavior (Rabin, 1993; Falk and Fischbacher, 2000; Dufwenberg and Kirchsteiger, 2004; Fehr et al., 1997; Fehr and Gächter, 2000), type-B players are likely to reciprocate in the form of higher public good contributions. Furthermore, higher transfer amounts are likely to be positively correlated with higher public good contributions by type-B players as they convey a stronger willingness to trust. However, decisions not to transfer despite the potential efficiency gains may be interpreted as distrust and in turn be reciprocated with low contributions. To summarize, we predict that *voluntary transfers are made* (H1). On the side of the receiving type-B players, we predict that contribution levels relative to their available endowment (after a potential transfer) are *higher when a voluntary transfer was received* as compared to the relative contributions levels of type-B players in Baseline (H2a) and *lower as in Baseline when a voluntary transfer was available but not made* (H2b).

Previous work has highlighted the importance of intentions for reciprocal behavior (e.g., Blount, 1995; Charness, 2004). A study by

[13] As an anonymous reviewer correctly noted, the efficiency gain in our case occurs on the way back (i.e., when type-B players contribute to the public good game which is in regard to the implementation of the multiplication parameter closer to gift exchange games, the trust game's sibling). Since trust and reciprocity are also key enablers of efficiency gains (see e.g., *Fehr* et al., 1998; Fehr and Gächter, 2000), but the gift exchange game is commonly used in the literature to study behavior in employment relationships, we base our predictions on the more generic reference to trust games.

Table 2
Probability of receiving a transfer in t in *transfer*.

	Pr(Receiving transfer in t)
Received transfer in t-1	−0.435***
	(0.101)
Relative contribution in t-1	0.001
	(0.001)
Received transfer in t-1 * Relative contribution in t-1	0.010***
	(0.001)
Round	−0.0098***
	(0.004)
Constant	0.326***
	(0.084)
Observations	720

Note: Estimation is based on a random effects linear probability model. The specification includes fixed effects for the second wave of data collection. Standard errors clustered at the group level are in parentheses. Level of significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Cox (2004) experimentally examines intention-based reciprocity and inspired the set-up of our *Exogenous* treatment condition. Cox compared receiver behavior in a standard trust game (treatment A) and a modified trust game, in which the transfer amounts were determined exogenously (treatment C). The exogenously determined amounts in treatment C, as in our experiment, were the amounts players had chosen in the endogenous set-up of treatment A. Cox found that with low amounts transferred by the sender, returned amounts in treatment C exceeded those in treatment A, albeit on a low level. The reverse was true for high amounts. While returned amounts were large in treatment A, most receivers returned nothing or only a small amount in treatment C. The intentional transfer was thus a pre-condition for reciprocal behavior. Consequently, we predict that *transfers are only reciprocated in terms of higher relative contribution levels to the public good when the transfer is voluntary and not exogenous* (H3).

Building on the above predictions, we hypothesize that overall average group contributions and public good size will reach higher levels when a voluntary transfer is possible.

5. Results

At first, to assess the average treatment effect, average group contributions and the size of the generated public good are analyzed for each treatment condition. Thereafter, we examine the realized transfers and type-specific decision-making of the players. At the end, average profits and earnings are compared.

5.1. Average group contributions and size of the public good

The left panel of Fig. 1 displays the average group contributions over the ten rounds for each treatment condition, measured relative to the endowment. In the *Baseline* condition, contribution rates start relatively high, at 65%, before settling at an average of 58% over the full ten rounds. In the *Transfer* treatment condition, the initial contribution rate is 71%, and contribution rates are, except for the last round, stable at this level (average of 70% over the ten rounds). Meanwhile, the contribution rates in the *Exogenous* treatment condition, where transfers are realized exogenously, start at 64% in the first round and average 60% over the full ten rounds. When probing for differences in the average group contributions using a Mann-Whitney Wilcoxon test (MWW), a statistically significant difference is found between the *Transfer* and *Baseline* condition ($z = -2.084, p = 0.037$) but not between *Exogenous and Baseline* ($z = -0.441, p = 0.663$) or *Transfer* and *Exogenous* ($z = 1.497, p = 0.136$).[14][15] A random effects GLS estimation taking into account the time trends (see Table A2 in the appendix) confirms this difference between *Transfer* and *Baseline,* albeit in a weaker form ($p = 0.060$).

Result 1a: *Average group contribution rates are higher when voluntary transfers are possible as compared to when no transfer option is given.*

When examining the size of the generated public goods instead, the *Transfer* condition outperforms the other two conditions. The public good size that is reached in the *Transfer* groups is, on average, 83 tokens, which is significantly larger than the size of 54 tokens in the *Baseline* groups (MWW, $z = -3.758, p = 0.000$) and 67 tokens in the *Exogenous* groups ($z = 2.203, p = 0.027$).[16] The right panel of Fig. 1 illustrates the resulting public good sizes for all treatments over the ten rounds, while in the appendix demonstrates that these results hold when time trends are accounted for.

Result 1b: *The average size of the public good is significantly larger when voluntary transfers are possible as compared to when no transfer*

[14] The unit of observation is the group. All tests are two-sided unless stated otherwise.The results presented in the manuscript on basis of Mann-Whitney-Wilcoxon tests remain when correcting for multiple hypotheses testing, see supplementary analysis in the online appendix.

[15] When the last round is excluded from the analysis, we get the following: *Transfer* vs. *Baseline*: z = −2.051, p = 0.040 and *Transfer* vs. *Exogenous:* z = 1.737, p = 0.083.

[16] Public good size in *Exogenous* vs. *Baseline*: z = −1.844, p = 0.065.

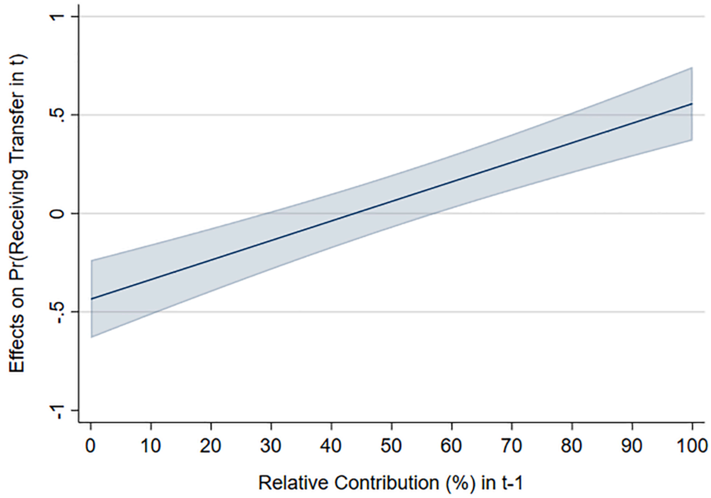

Fig. 2. Average marginal effect of having received a transfer in t-1 on the likelihood of receiving a transfer in t for different contribution levels in t-1 with 95% confidence intervals.

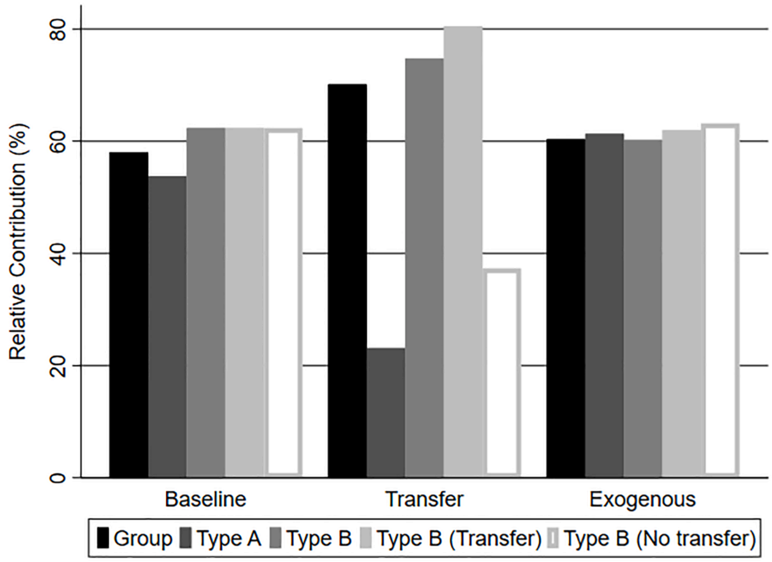

Fig. 3. Average relative contributions by player type and treatment condition. The graph depicts the average contributions of different player types as percentages of their respective endowment after transfers by treatment condition. *Type B (Transf)* refers to type-B players in rounds when a transfer was made, and *Type B (No transf)* refers to type-B players in rounds when no transfer was made.

option is given or when transfers are exogenously imposed.

5.2. Transfer rates

The observed differences in public good sizes suggest that resources within groups are allocated and used more efficiently in the *Transfer* condition. In the next step, we analyze the respective transfer rates and corresponding reactions of type-B players. In the *Transfer* condition, type-A players frequently and extensively use the transfer option. In the first round, 68% of type-A players transfer all of their available endowment and 23% transfer half. Over the course of the interaction rounds, the composition of transfers remained relatively stable (see Fig. A1 in the appendix). Overall, 63% of the transfers are equal to the full endowments and 15% to half of the endowments. Out of 40 type-A players, only two never made a transfer, while 13 transferred the maximum amount each time. This provides support for Hypothesis 1.

Result 2: *When voluntary transfers are possible, type-A players make use of it and frequently transfer the maximum possible amount.*

When type-B players receive a transfer, they contribute in 92% of the cases at least the entrusted (i.e., the transferred amount), and in 78% of the cases they contribute everything. The low defection rate is essential for stable transfer patterns. Table 2 shows the estimation results for the probability of receiving a transfer, while Fig. 2 illustrates the model's interaction term, demonstrating the average marginal effect of having received a transfer in t-1 on the likelihood of receiving a transfer in t for different contribution levels in t-1. As can be seen, for type-B players who received a transfer in the previous round, compared to those who have not, the likelihood of receiving another transfer in the current round significantly drops from their previously realized contributions levels.

Result 3: *The transfer-receiving type-B players almost always contribute at least the transferred amount to the public good. A significant percentage of type-B players reciprocate the transfer by contributing their entire endowment to the public good.*

Given the high rates of transfers and the higher productivity of type-B players, it is not surprising that the size of the realized public good is significantly larger in *Transfer* relative to that in *Baseline.* Here, the comparison with the *Exogenous* condition is more informative. Theoretically, groups could reach in *Exogenous* the same maximum public good size as in *Transfer*. However, as previously seen, the realized size is not identical. To understand why this is the case, we examine the individual contribution decisions by player type and realized transfer option.

5.3. *Relative contributions to the public good*

Fig. 3 presents, according to player type, the average relative contribution rates compared to the available endowment (after transfer). The average relative contributions of *type-A* players are significantly smaller in the *Transfer* condition (23%) than the average relative contributions in the *Baseline* condition (54%) (MWW: $z = 3.678$, $p = 0.000$). Pairing this with the high rates of realized transfers shows that *type-A* players who want to contribute in *Transfer* mostly did so via the transfer option. In *Exogenous*, type-A players contribute on average 61%, which is significantly more than in *Transfer* (MWW: $z = -3.635$, $p = 0.000$) but not significantly different to type-A players' contributions in *Baseline* ($z = -1.085$, $p = 0.282$). To assess differences in relative contributions depending on whether and which type of transfer has been implemented, we use the Wilcoxon signed-rank test (WSRT).[17] When type-A players chose not to make a transfer in the *Transfer* condition, contributions remain positive but at a much lower level. The average contribution rates of type-A players who decide against the transfer are at 13% and are at 32% when they decide to transfer only half of their endowment (exact WSRT, $S = 6.000$, $p = 0.622$).[18] In *Exogenous*, where the same transfers were exogenously implemented, contribution levels are comparable whether or not an exogenous transfer occurred (62% vs. 61%, exact WSRT: $S = -2.000$, $p = 0.820$). As a result, we see for type-A players in rounds with and without transfers higher contributions in *Exogenous* than in *Transfer* (MWW: transfer rounds: $z = -2.547$, $p = 0.01$, no transfer rounds: $z = -3.990$, $p = 0.000$).

For the "poorer" type-B players, we find, in line with Hauser et al. (2016), that they already contribute in *Baseline* with 62%—a higher proportion of their endowment than that seen for the type-A players. In the *Transfer* condition, this proportion increases to 75%, which constitutes a significant difference to the contribution levels observed in *Baseline* (MWW, $z = -2.072$, $p = 0.038$) and in *Exogenous* ($z = 2.167$, $p = 0.030$) where type-B players contribute, on average, 60%.[19]

Distinguishing between rounds with and without transfers provides more information regarding type-B players' motivations to contribute at high levels. In *Transfer*, contribution levels are at 37% in rounds when no transfer from the type-B players is received and at 81% when a transfer is received (WSRT, $z = 3.771$, $p = 0.000$). Compared to *Baseline*, these contribution levels of type-B players are significantly lower in the case of no transfer (MWW, $z = 3.105$, $p = 0.002$) and significantly higher in the case of transfers ($z = -2.863$, $p = 0.004$).[20] This finding provides support for Hypotheses 2a and 2b.

Result 4a: *Receiving a voluntary transfer, type-B players reciprocate this action by contributing higher relative levels to the public good as compared to when no transfer option is given.*

Result 4b: *When type-A players choose not to make a transfer, type-B players, in contrast, contribute lower relative levels than when no transfer option is given.*

Focusing on the changes in endowments, we find that in *Exogenous*, type-B players do not change their contributions with higher endowments resulting from exogenously implemented transfers (no transfer vs. transfer: 62% vs. 63%, WSRT, $z = -0.726$, $p = 0.489$).[21] Thus, for the reaction of type-B players, it is important that their increased endowment occurs as a result of a transfer chosen by their interaction partner. When making a transfer, type-A players in *Transfer* show trust, and type-B players reciprocate this trusting action.

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[17] The Wilcoxon signed-rank test takes the dependency in the data (i.e. multiple observations from the same person) into account.

[18] Only type-A players who did *not* transfer their full endowment can still make contributions. As outlined in the previous section, type-A players predominantly chose to transfer their total endowment, meaning that observations here are relatively small. To account for these small sample sizes, we perform exact Wilcoxon signed-rank rests at this point.

[19] In absolute terms, average contributions of type-B players are 9.35 (sd: 4.39) in *Baseline,* 20.44 (9.08) in *Transfer*, and 15.47 (sd: 8.19) in *Exogenous.* These contribution levels differ among all three treatment conditions at a 1% significance level.

[20] Examining the different constellations of realized transfers gives a more detailed insight into the reactions of the type-B players. As shown in Section 5.2., type-A players send a transfer equal to half of their endowment in 15% of the cases, which is received by only one of the type-B players. Those receiving type-B players contribute 76% of their (new) endowment, and the non-receivers contribute 59% (WSRT: z = 2.197, p = 0.030). In 63% of the cases, type-A players transfer their full endowment. They do so primarily by splitting the transfer between the two type-B players (68% of the time). Type-B players respond in this case by contributing on average 83% of their endowment. When the full transfer is instead directed to only one type-B player, the receiving type-B player contributes 80% and the non-receiver 67% (WSRT: z = 1.691, p = 0.093).

[21] As a consequence, contributions by type-B players in *Transfer* were also higher than the corresponding type-B contributions in *Exogenous* when a transfer was made (MWW, z = 2.740, p = 0.006) and lower in the case of no transfer (MWW, z = - 2.593, p = 0.009).

Comparing in *Transfer* the sizes of the transfer, we find that higher transfers (i.e., of the full endowment) also lead to higher contribution rates among type B players in the *Transfer* condition. This pattern is absent in *Exogenous,* reiterating the critical role of the deliberate decision to transfer to motivate the reciprocity of type-B players in the form of higher contributions to the public good. The regression analysis shown in Table A3 in the appendix provides support for these results. In summary, we find that the positive (negative) changes in contribution levels of type-B players following type-A players' decisions (not) to transfer are a response to the intentional act of the latter and cannot be fully explained by the resulting changes in endowment as implemented in the *Exogenous* treatment condition. With this we find support for Hypothesis 3.

Result 5: *Changes in the relative contribution levels of Type-B players can be attributed to the intentional transfer of type-A players and cannot be fully explained by higher endowments resulting from the transfer.*

5.4. Profits

Efficiency gains established by transfers are reflected in the resulting profits. Mirroring the earlier result on the size of the public good, average profits per round in *Transfer* are significantly higher than in *Baseline* and *Exogenous* (39 tokens vs. 30 and 35 tokens, MWW, $z = -4.586$, $p = 0.000$ and $z = 2.433$, $p = 0.015$). Considering the heterogeneity among players, we find that type-A players benefit from the option of voluntary transfers (35 tokens in *Baseline* vs. 41 tokens in *Transfer*, MWW: $z = -3.965$, $p = 0.000$), but lose out when exogenous transfers are in place (30 tokens in *Exogenous*, for *Baseline* vs. *Exogenous:* $z = 1.912$, $p = 0.056$; and for *Transfer* vs. *Exogenous:* $z = 4.292$, p-values $= 0.000$). Type-B players, on the other side, benefit from both transfer schemes compared to their counterparts in *Baseline* (27 tokens vs. 38 tokens in *Transfer* (MWW, $z = -5.472$, $p = 0.000$) and vs. 37 tokens in *Exogenous* ($z = -4.793$, $p = 0.000$), with no significant difference between the two transfer schemes (MWW, $z = 1.221$, $p = 0.224$).

For type-A players in *Transfer*, earnings in rounds with a transfer are non-significantly higher than in rounds without a transfer (40 vs. 37 tokens, WSRT: $z = -0.784$, $p = 0.452$).[22] By contrast, for type-B players, transfers lead to a remarkable difference in profits (in *Transfer*: 43 in rounds with a transfer vs. 20 in rounds without, WSRT: $z = 3.920$, $p = 0.000$).[23] Lastly, type-B players who in *Transfer* always contribute at least the transferred amount fare significantly better than type-B players who do not (MWW, $z = 3.311$, $p = 0.001$), with 67% belonging to the group of type-B players that contributed at least the transferred amount in all rounds.

Result 6: *Average group profits are significantly higher when a transfer option is provided, with voluntary transfers leading to the best result. Type-A players earn significantly more under the voluntary transfer scheme. Type-B players earn significantly more when a transfer scheme is in place, with no difference in whether the transfer is voluntary or exogenously imposed.*

The results presented here are derived based on a partner-matching protocol in which players interact in the same group over the course of the interaction rounds and are able to track the actions of their interaction partners and thus build up a reputation over time (e.g., Bracht and Feltovich, 2009). As previous research has shown, this setting strengthens the role of trust and reciprocity and consequently boosts cooperation (see Croson (1996) for public good games and Bohnet and Huck (2004) for trust games), which is partially because violations against the reciprocity norms can be punished in later rounds. As a consequence, we assumed for our research that endogenous transfers are realized and reciprocated more often than in a setting where individuals interact anonymously. To test this theory, we conducted the experiment using a smaller sample under a stranger-matching protocol. The detailed analysis can be found in the online appendix.[24] As expected, average group contributions, public good sizes, and average profits are smaller in both transfer conditions when the stranger-matching protocol was implemented than when the partner-matching protocol was implemented. Moreover, defection is more common when the stranger-matching protocol is used.

5.5. Summary of the results

To summarize, we found that allowing for a resource transfer from the richer to the poorer but more productive players has an overall positive effect on the provision of public goods. A significant majority of type-A players transfer half or all of their endowment, although these transfers were unconditional in our experiment (i.e., players risked low or zero earnings). Type-B players, in turn, commonly reciprocate the trusting action with high contributions and low defection rates. However, in the case of no transfer, cooperation rates among type-B players are significantly lower than when no transfer option is given. This suggests that the decision not to transfer is interpreted as distrust and accordingly reciprocated with low contributions. The additional exogenous condition shows that the pure reallocation of resources can only explain these behavioral patterns to some degree. When transfers are implemented exogenously, type-B players do not reciprocate the transfer with higher contribution levels. Therefore, the intentional decision to transfer is vital. By performing a voluntary transfer, type-A players signal their trust and willingness to cooperate, which type-B players in turn reciprocate.

6. Discussion and conclusion

Previous research has shown that, in the presence of free-riding incentives, cooperation can be difficult to achieve, particularly in

[22] In *Exogenous*, round earnings of type-A players in rounds with a transfer are non-significantly lower than in rounds without (WRST, 30 vs. 34, $z = -1.167$, $p = 0.254$).

[23] For *Exogenous*: 40 vs. 28 WSRT, $z = 3.823$, $p = 0.000$.

[24] https://osf.io/9n7d3/?view_only=208c2ea1e96c42b795ea0df507e294d9

situations involving heterogeneous actors, which is often the case outside the laboratory. In the case of an asymmetric distribution of endowment and productivity heterogeneity, meaning that the "poor" are more productive than the "rich", our results show that the simple mechanism of allowing a transfer of resources can significantly increase public good provision. These transfers in our experiment are purely voluntary and do not require any exogenous intervention. Successful groups use the transfers to exploit efficiency gains and to overcome conflicting contribution norms by establishing a positive reciprocal relationship. However, not all groups succeed in cooperation.

To be more specific, we find that a surprisingly large share of players transfer their entire endowment, even in the first round of play. Numerous experiments have shown that humans exhibit a "taste" for efficiency. For instance, in a study by Kritikos and Bolle (2001), individuals accept a more unequal distribution of payoffs to their disadvantage in order to achieve a more efficient outcome overall. Galeotti et al. (2019) show that players are more concerned with efficiency than equity in bargaining games. Barrett and Dannenberg (2017) demonstrate that subjects prefer the more efficient game (in terms of higher maximum payoff possible) over the game with lower payoffs but higher chances of realizing these lower payoffs. This concern for efficiency can explain why type-A players in our experiment are willing to risk their endowment for the opportunity to achieve the most efficient solution.

Second, type-B players with low endowment but high productivity usually reciprocate transfers with very high contribution rates, even when the other B-player was the recipient of the transfer. The comparison with the exogenous treatments shows that these high cooperation rates are only realized when an endogenous transfer occurs. When transfers are exogenously imposed, we do not find that type-B players respond to the transfer in the same way. This difference cannot be explained by standard economic preferences or inequality aversion, but the behavior fits relatively well the predictions based on intention-based reciprocity. The positive correlation between higher transfers and higher subsequent contributions in the transfer treatments also corresponds to the predictions based on reciprocity concerns.

Third, if the option of a transfer is given but not used, this seemed to be perceived by the players as a signal of non-cooperation or unwillingness to trust and was reciprocated accordingly. It is therefore important to investigate the conditions under which a transfer is more likely to occur.

Fourth, compared to the asymmetric setup adopted by Hauser et al. (2019), the contribution level in our baseline treatment is considerably higher: 63% compared to 46% in Hauser et al. (2019). There were several differences between the two experiments: Subjects in Hauser et al. (2019) were recruited via Mturk and play online, they play in groups of two players with a productivity parameter of 1.3 and 1.9, and the game lasts at least 20 rounds with an indefinite ending thereafter. While the first difference most likely has a negative effect on contributions, smaller group sizes and indefinite endings usually have a positive impact. Meanwhile, the effect of the difference in the productivity parameter is less clear as it differs from our setup in terms of its level as well as in its skewness.

The results of this paper are good news for heterogeneous groups in situations with repeated interactions and observability of behavior. By simply allowing group members to enter into a trusting and reciprocal relationship and to exploit efficiency gains, cooperation rates and thereby public good provision can be increased significantly.

While the use of a laboratory experiment enabled us to identify causal effects, the simplification and level of abstraction that came with it impose a number of limitations. Essential for us are the following: Transfers outside the laboratory are typically not given unconditionally. In our experiment the players with high endowment but low productivity (type-A) are able to observe other players' behavior but are unable to tie their transfers to conditions or to punish in case recipient's behavior is not as intended. While such an enforcement mechanism may be important, in reality it is often difficult or even impossible for the donor to determine whether funds are actually used as intended (see Devarajan and Swaroop (2000) for a discussion on the fungibility of development aid). Conditions or sanctions, though declared ex-ante, may thus in reality not be enforceable.

Furthermore, our experiment allows for substantial efficiency gains through transfers. With the high productivity parameter, type-B players have to contribute only 50% or more of the received transfer amount so that the transfer pays off. Additionally, the high productivity parameter reduces the cost of contributing to the public good and thus facilitates reciprocation. A valuable investigation for future research may be to examine how sensitive the observed reciprocity is to variations in the productivity heterogeneity.

Lastly, a feature that is usually present in real-world situations, such as teamwork settings or in the international community, but is absent in our experiment is communication. Communication has been shown to increase cooperation in homogenous groups (Ostrom et al., 1992; Balliet, 2010), while its impact has been found to be more ambiguous in heterogeneous groups (Hackett et al., 1994; Chan et al., 1999). Thus, it is a priori not clear how communication would interact with the transfer possibility. On the one hand, the ability to communicate could strengthen the group feeling and increase the willingness to trust, thereby increasing the number of positive transfers and subsequent contributions. On the other hand, with prior bargaining the transfers could be interpreted more as a strategic action than a trusting one, which could increase the likelihood of non-reciprocal behavior accordingly. Hence, incorporating communication could provide an interesting starting point for an extension of this experiment.

Declaration of Competing Interest

None.

Data availability

The data, analysis files and experimental instructions are publicly available via the Center for Open Science: https://osf.io/9n7d3/?view_only=208c2ea1e96c42b795ea0df507e294d9

Acknowledgements

This work was financially supported by the European Union (EU) Horizon 2020 program, action ERC-2014-STG, Project HUCO, Grant Number 636746. The experiment was approved by the Institutional Review Board of the German Association for Experimental Economic Research (https://gfew.de/ethik/qpAfJtwu). We thank Astrid Dannenberg, the editor David K. Levine and three anonymous reviewers for their valuable comments. We thank G. Simmonett for the proofreading of the manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2023.104561.

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