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Voting for Burden Sharing Rules in Public Goods Games

Carlo Gallier[1] · **Martin Kesternich**[1] · **Bodo Sturm**[1,2]

Abstract We experimentally investigate whether groups of heterogeneous agents can reach an agreement on how to share the costs of providing a public good. Thereby, we explore the performance of different burden sharing rules being implemented either endogenously or exogenously. In case of an endogenously implemented burden sharing rule, subjects vote for different burden sharing schemes either by unanimity or majority vote. Despite the fact that preferences for the allocation schemes differ among agents, most groups agree upon a common scheme, and consequently avoid an uncoordinated action. Our results reveal both the opportunities and risks of burden sharing negotiations. We find average efficiency levels to increase in case an agreement is reached. If groups however fail to agree upon a common rule, cooperation collapses and efficiency levels decrease compared to a voluntary contribution mechanism being exogenously imposed. Most importantly, agents who face a voting decision on average receive higher payoffs than agents in an exogenously implemented voluntary contribution mechanism and do not earn less than participants in any externally determined burden sharing rule.

Keywords Public goods · Experiment · Cooperation · Burden sharing · Minimum contribution rules · Voting · Endogenous institutions · Agreement formation

JEL Classification C72 · C91 · C92 · D02 · D72 · H41

✉ Martin Kesternich
kesternich@zew.de

Carlo Gallier
gallier@zew.de

Bodo Sturm
bodo.sturm@htwk-leipzig.de

[1] Centre for European Economic Research (ZEW), L7, 1, 68161 Mannheim, Germany

[2] Leipzig University of Applied Sciences, 04277 Leipzig, Germany

1 Introduction

Inducing contributions to public goods remains an important endeavor and is particularly demanding when sovereign agents have different interests due to heterogeneous preferences. Free riding incentives prevent the voluntary provision of a public good and every institutional design which aims at countervailing free riding has to address the question of a fair distribution of the costs and benefits from providing public goods. The experimental literature suggests rule-based contribution schemes which are inspired by different fairness norms as being effective in enhancing cooperation (e.g., Orzen 2008; Dannenberg et al. 2014; Kesternich et al. 2014a, b). In such a scheme, agents have to agree upon a common group provision level of the public good by knowing that the associated costs are distributed among the agents according to an exogenously predetermined burden sharing rule. While the previous papers devoted to this issue show that exogenously imposed burden sharing rules are able to increase efficiency levels in contrast to a voluntary contribution mechanism (*VCM*), we argue that the external implementation of a certain burden sharing scheme is rarely a feasible or desirable option due to sovereign agents. As an important example, in most international negotiations parties have to voluntarily agree upon a joint decision. Regarding international climate negotiations as an important application, a variety of rules for carbon emissions reductions among participating countries is conceivable and it constitutes a major challenge for participants to agree upon a common rule (Lange et al. 2007, 2010; Kesternich et al. 2014c). Burden sharing rules being currently discussed within international climate policy are inspired by different fairness norms. These fairness norms comprise, for instance, *Sovereignty*, calling for equal contributions from all agents (e.g., equal percentage reductions of emissions), or *Need*, which implies relatively low obligations for developing countries and economies in transition and consequently shifts the burden towards agents with substantial economic capacity (Johansson-Stenman and Konow 2010). In most international negotiations, the consensus principle serves as the primary decision making tool. Even though the term consensus does not necessarily equal unanimity but is rather defined as "the absence of any formal objection" (Schwarte 2011) in many conventions, it is often claimed that a consensus enables one single party to block and delay decisions. Therefore, ongoing debates in international climate negotiations on possible changes in the decision-making process include calls for a supranational authority or an international framework being able to enforce the distribution of global mitigation efforts, for instance, through adjusting the consensus principle by establishing some form of majority voting (e.g., Vogel 2014). Also in the management of local commons like irrigation systems, different rules that regulate the distribution of costs and benefits of cooperation among group members are subject to discussions. Ostrom (1990) demonstrates that governing schemes which are characterized by rules that distribute costs and benefits equivalently lead to comparatively high cooperation levels. Even in case of local public goods where enforcement problems appear less severe, an agenda-setter such as a local government may give agents the opportunity to agree on a contribution scheme by themselves instead of determining the burden sharing exogenously.

Our experimental design enables us to analyze the performance of different burden sharing rules being endogenously implemented by the participating agents themselves, both to an exogenously given *VCM* and to a setting where allocation schemes are predetermined by an agenda setter. We thereby apply a design with players differing in their initial endowments which based on our previous findings creates substantial tensions in the different rule-based contribution schemes (Kesternich et al. 2014b). In particular, we investigate whether (i) sovereign and heterogeneous agents are able to agree upon a joint burden sharing rule, whether

(ii) agreement formation does affect contribution behavior and whether (iii) efficiency gains from exogenously implemented schemes persist in a setting with endogenously induced institutions.

Our three-player repeated public goods game is implemented either as a *Single-* or as a *Multi-Phase Game*. Subjects in the *Multi-Phase Game* play a collective-choice and a contribution phase. In the collective-choice phase, subjects vote for a joint burden sharing rule in a repeated voting decision. In order to acknowledge different levels of sovereignty, we implement either unanimity or a majority vote. Furthermore, we consider three different burden sharing rules: equal contributions from all group members to the public good (*eqcont*), equal payoffs among all group members (*eqpay*), and contributions to the public good that are proportional to the participants' initial endowment (*propcont*). If a burden sharing rule obtains a sufficient majority in the collective-choice phase, it is implemented in the contribution phase. In case a sufficient majority cannot be reached after three voting rounds, the agreement formation has failed and subjects end up in a *VCM*. In the *Single-Phase Game*, subjects only play the contribution phase and make their contributions to the public good according to a burden sharing scheme being exogenously predetermined. In our experimental setting, all rule-based contribution schemes are based on the principle of the "smallest common denominator" which ensures veto power for all negotiating parties and comprises two steps: First, all agents can propose a minimum group contribution level to the public good. Then, the minimum of all proposals is selected and allocated among subjects according to a (pre-defined) burden sharing rule.

Our findings indicate that most groups agree upon a common scheme, and consequently avoid an uncoordinated action given that preferences for the allocation schemes differ among agents. The results reveal both the opportunities and risks for burden sharing negotiations. In case an agreement is reached we find that average efficiency levels increase compared to an externally implemented *VCM*. If groups however fail to agree upon a common rule, cooperation collapses and efficiency levels decrease compared to a *VCM* being exogenously imposed. Most importantly, we observe that it is beneficial to provide endogenous institution formation on a joint burden sharing agreement at the aggregate level, i.e., including both groups that reach a consensus upon a joint burden sharing rule and groups that fail to agree upon a common scheme. On average, agents who face a voting decision receive higher payoffs than participants in the external implemented *VCM*.

The remainder of this paper is organized as follows: Section 2 provides an overview of the related literature. Section 3 describes the experimental design and derives our theoretical predictions. We present the experimental results in Sect. 4 and Sect. 5 concludes the paper.

2 Related Literature

As soon as the provision of public goods involves heterogeneous agents, any voluntary contribution mechanism has to cope with burden sharing issues. By summarizing the literature on contribution patterns in heterogeneous public goods games, Ledyard (1995) and Zelmer (2003) reveal that heterogeneity lowers average contribution rates in public goods experiments. Fisher et al. (1995) find evidence that players with high marginal per capita returns contribute less in heterogeneous groups with agents receiving low benefits from the public good compared to a homogeneous setting. Tan (2008) reports that heterogeneity with respect to contribution costs lowers cooperative behavior. Ambiguous effects have been shown with respect to the effect of inequality of initial endowments, indicating both negative (e.g., Anderson et al. 2008; Cherry et al. 2005; van Dijk et al. 2002) and potential positive effects (e.g.,

Chan et al. 1996, 1999). Georgantzìs and Proestakis (2011) show positive impacts of heterogeneity in lab endowments on contribution levels, at least as long as subjects are not aware of the real wealth inequality of the group members. By tying contribution behavior to social norms based on different fairness principles, Reuben and Riedl (2013) reveal that players contribute proportionally to their endowments if punishment is allowed in a setting with endowment heterogeneity.

There are two additional strands of experimental literature which are particularly important for our research questions. First, recent papers study the effect of rule-based contribution schemes on the voluntary provision of public goods. In such allocation schemes, players first agree upon a common group provision level of a public good which is based on a minimum contribution mechanism. The associated costs for providing the joint project are then distributed among players according to a specific predetermined burden sharing rule. Orzen (2008) and Dannenberg et al. (2014) show the benefits of this contribution mechanism for groups of homogeneous players in contrast to a *VCM*. When players are identical, there is only one fair sharing norm which assigns the same burden to all agents. In contrast, different burden sharing rules—inspired by different fairness norms—may seem plausible as soon as agents are heterogeneous. Remarkably, a burden sharing rule that aims at equalizing payoffs leads to substantial cooperation gains for providing a public good that generates heterogeneous benefits to agents (Kesternich et al. 2014a). Further experimental investigation, however, indicates that efficiency gains from these rule-based contribution schemes are limited in case of endowment heterogeneity and that the perception on various contribution norms is sensitive to the circumstances under which the different positions accrued (Kesternich et al. 2014b). In all these experiments, the different allocation rules are exogenously imposed instead of being endogenously determined by the group itself. An external implementation is rarely a feasible option among sovereign agents, e.g., for the provision of international public goods, and moreover may not be desirable in many cases.

Second, our experimental design is tied to a growing number of experiments on the emergence and effects of endogenous institutions in social dilemma situations. An important challenge always remains on whether or not institutions can emerge endogenously within groups of sovereign agents with conflicting interests. For instance, Plott and Levine (1978) as well as Hoffman and Plott (1993) have already studied how agents with opposing interests form agreements, and they emphasize that particular procedures which limit or favor the accumulation of information are at least as important as the structure of preferences in determining outcomes. Experimental studies show that sanctioning or rewarding mechanisms are successfully formed in public good games and that they also affect the behavior of the respective agents (e.g., Ertan et al. 2009; Kosfeld et al. 2009; Sutter et al. 2010). Kittel et al. (2011) find that payoffs tend to equalize in groups of unequally endowed agents who have to agree upon redistribution by majority due to a coalition against the rich player. Thus, the leading question concerning the effect of endogenously implemented institutions covers important aspects of procedural fairness: Individuals do not only care about outcomes, but also pay attention to the conditions and processes leading to these outcomes (e.g., Frey et al. 2004). Many experiments focusing on the impact of endogenously implemented institutions on cooperation behavior tend to find an *endogeneity premium*: Endogenously implemented institutions lead to more cooperative behavior when compared to the same institutions being implemented exogenously (e.g., Margreiter et al. 2005; Tyran and Feld 2006; Ertan et al. 2009; Kosfeld et al. 2009; Sutter et al. 2010; Dal Bó et al. 2010; Balafoutas et al. 2013). Dal Bó et al. (2010) attribute this observation both to a selection effect and to an endogeneity effect. While players who vote for a certain institution may differ from those who oppose it (selection effect), the endogeneity effect disentangles potential differences in the decision

behavior between endogenously or exogenously determined settings. In the same manner, empirical studies indicate that stronger direct democratic participation rights are associated with an increase in cooperation and a decrease in, for instance, tax evasion (e.g., Pommerehne and Weck-Hannemann 1996).

3 Experimental Design and Theoretical Predictions

Participants in the *Multi-Phase Game* play a collective-choice and a contribution phase. In the collective-choice phase, subjects themselves determine the contribution scheme to be implemented in the contribution phase. Participants in the *Single-Phase Game* play only the contribution phase whereby the different contribution schemes are exogenously given.

3.1 Single-Phase Game

In the *Single-Phase Game*, the contribution phase contains one of four different allocation rules: three rule-based contribution schemes (*eqcont*, *eqpay* and *propcont*) and a standard voluntary contribution mechanism (*VCM*).

In all contribution schemes, the payoff to player i, π_i, is determined by a linear public goods game and given by

$$\pi_i = e_i - q_i + bQ$$

where e_i marks the initial endowment, q_i the individual contribution to the public good, b the marginal per capita return from the public good for player i, and $Q = \sum_{j=1}^{n} q_j$ the aggregated provision level. Players differ with respect to their initial endowment. The endowment as well as contribution levels and payoffs are expressed in LabDollar (LD). Each group of $n = 3$ players consists of one "low-type" player (*type20*) with an initial endowment of $e_{type20} = 20$, one "middle-type" player (*type30*) with $e_{type30} = 30$, and one "high-type" player (*type40*) with $e_{type40} = 40$. Thus, there is a total group endowment of $E = \sum_{i=1}^{n} e_i = 90$. Finally, we assume the marginal benefit from the public good to be $b = 0.6$ and the marginal costs for investing into the public good to be equal to one.

In the baseline *VCM*, agents simultaneously determine their individual contributions to the public good q_i. Since their marginal costs from investing into the public good exceed their individual benefits, standard theory predicts full free riding and zero contributions for all players and individual payoffs of $\pi_i = e_i$.

Our rule-based contribution schemes comprise two stages: In the first stage, the minimum stage, all players simultaneously suggest a minimum group provision level $Q_i^{min} \in [0, 90]$.[1] The smallest suggested proposal consequently determines the lower bound for aggregated contributions in the second stage, i.e., $Q^{min} = \min_{j \in S} Q_j^{min}$ where S is the set of players in a group. In the individual contribution stage, the minimum individual contribution level, q_i^{min}, is derived from the binding group minimum provision level, Q^{min} according to a specific burden sharing rule, i.e., $q_i^{min}(Q^{min})$, whereby subjects have to contribute at least the minimum contribution level q^{min}, i.e., $q_i \geq q_i^{min}$. However, players can exceed these minimum requirements and voluntarily contribute more. We cover three different rule-based contribution schemes:

[1] In our experiment, integer multiples of three are required for Q_i^{min}.

Equal-Contribution Scheme (eqcont)

If a rule-based contribution scheme requires equal contributions (*eqcont*) from all players to the public good, the individual minimum contribution levels are given by

$$q_i^{min} = \frac{1}{n} Q^{min}$$

for sufficient low group provision levels. Thus, the binding minimum proposal, Q^{min}, is equally distributed across all group members. However, it should be taken into account that in all burden sharing schemes, it is obligatory that the desired aggregated provision level Q^{min} is provided by the group and that $q_i^{min} \in [0, e_i]$. Therefore, it appears that *eqcont* may require higher contributions from subjects with high endowments if the equal contribution rule would requires contributions from low-type players to exceed their initial endowment. More formally, contributions of all group members are given by $q_i^{min} = \frac{1}{n} Q^{min}$ for $Q^{min} \in [0, 60]$. If $Q^{min} \in [60, 80]$, minimum contributions of *type20* players are $q_{type20}^{min} = e_{type20}$ and therefore lower than those of *type30* and *type40* players, $q_{type30}^{min} = q_{type40}^{min} = \frac{1}{n-1}(Q^{min} - e_{type20})$. If $Q^{min} \in [80, 90]$, minimum contributions are given by $q_{type20}^{min} = e_{type20} < q_{type30}^{min} = e_{type30} < q_{type40}^{min} = \frac{1}{n-2}(Q^{min} - e_{type20} - e_{type30})$.

In the *eqcont* scheme, *type20* and *type30* players have a weakly dominant strategy to suggest $Q_i^{min} = E$. For them, the marginal benefit from increasing their group's binding minimum contribution level exceeds its costs for all $Q_i^{min} \in [0, E]$. Choosing $Q_i^{min} < E$ would either reduce their own payoff (i) if they set the binding minimum, or (ii) would not change the payoff if their minimum proposal was not pivotal. Following this intuition, *type40* players have a weakly dominant strategy to choose $Q_i^{min} = 78$ since their marginal payoff is only positive if $Q^{min} \leq 80$.[2] Since the smallest proposal is binding and we assume agents to choose an equilibrium strategy which maximizes their payoff in all subgames, an equilibrium that comprises those strategies which are weakly dominant in all subgames, i.e., a subgame perfect equilibrium in weakly dominant strategies, is characterized by $Q^{min} = 78$ with $q_{type20}^{min} = 20$ and $q_{type30}^{min} = q_{type40}^{min} = 29$. Given that $q_i = q_i^{min}$, this results in individual payoffs of $\pi_{type20} = 46.8$, $\pi_{type30} = 47.8$ and $\pi_{type40} = 57.8$ and, consequently, an aggregated group payoff of $\Pi = 152.4$.[3]

Equal-Payoff Scheme (eqpay)

If a rule-based contribution scheme aims at reaching equality in payoffs *(eqpay)* among all group members and if all types of players have different initial endowments but the same marginal benefits from the public good, equating $\pi_{type20} = \pi_{type30} = \pi_{type40}$ and solving for q_i^{min} implies that

$$q_i^{min} = e_i - \frac{1}{n}\left(E - Q^{min}\right)$$

for sufficiently high group provision levels. Note that in the *eqpay* scheme, the desired aggregated provision level Q^{min} may not entirely allow for a payoff equalization since

[2] Mathematically, the weakly dominant strategy of *type40* players is to choose $Q_i^{min} = 80$, but the minimum group provision level has to be an integer multiple of three. Therefore, the weakly dominant strategy is to choose the greatest integer multiple of three below 80.

[3] See Supplementary Material Section 1 for a graphical illustration and the analytical solution.

we do not take a direct redistribution of initial endowments between group members into account and $q_i^{min} \in [0, e_i]$. This implies that payoff equalization among all group members could be achieved if $Q^{min} \in [30, 90]$. If $Q^{min} < 30$, payoffs are equalized as far as possible. More formally, if $Q^{min} \in [9, 30]$, $q_{type20}^{min} = 0$ and $q_{type30}^{min} = q_{type40}^{min} = e_j - \frac{1}{n-1}\left(e_{type40} + e_{type30} - Q^{min}\right)$. If $Q^{min} \in [0, 9]$, $q_{type20}^{min} = q_{type30}^{min} = 0$ and $q_{type40}^{min} = Q^{min}$. For instance, if $Q^{min} = 24$, this scheme would require $q_{type20}^{min} = 0$, $q_{type30}^{min} = 7$ and $q_{type40}^{min} = 17$. But nevertheless, payoff equality is not reached due to the endowment heterogeneity. If $q_i = q_i^{min}$ individual payoffs are then given by $\pi_{type20} = 34.4$, $\pi_{type30} = \pi_{type40} = 37.4$.

In the *eqpay* scheme, we expect all players to suggest full contribution levels, i.e., $Q_i^{min} = E$. *type20* and *type30* players have a weakly dominant strategy to suggest $Q_i^{min} = E$. By anticipating the weakly dominant strategy of *type20* and *type30* players, *type40* players also maximize their payoff by suggesting $Q_i^{min} = E$. This allocation would lead to individual minimum contributions of $q_{type20}^{min} = e_{type20}$, $q_{type30}^{min} = e_{type30}$ and $q_{type40}^{min} = e_{type40}$, given that $q_i = q_i^{min}$ determines equal individual payoffs for all group members of $\pi_{type20} = \pi_{type30} = \pi_{type40} = 54$ and a group payoff of $\Pi = 162$.[4]

Proportional-Contribution Scheme (propcont)

If a rule-based contribution scheme requires individual contributions to be proportional to the players' initial endowment (*propcont*), individual minimum contribution levels are given by

$$q_i^{min} = \frac{e_i}{E} Q^{min}.$$

Thus, the binding minimum proposal, Q^{min}, is distributed among group members according to their proportion of the total endowment, implying that individual minimum contributions increase with players' initial endowments. In this case, all players have a weakly dominant strategy to suggest full contribution levels, i.e., $Q^{min} = E$, since their marginal benefit from increasing the group's minimum contribution level exceeds its costs for all $Q^{min} \in [0, E]$. This allocation is a subgame perfect equilibrium in weakly dominant strategies and would lead to individual minimum contributions of $q_{type20}^{min} = e_{type20}$, $q_{type30}^{min} = e_{type30}$ and $q_{type40}^{min} = e_{type40}$. Furthermore, given that $q_i = q_i^{min}$ individual payoffs are $\pi_{type20} = \pi_{type30} = \pi_{type40} = 54$ and the aggregated group payoff is $\Pi = 162$.

Thus, assuming that subjects behave according to standard theory and that they play their own minimum contribution level, i.e., $q_i = q_i^{min}$, we can derive the following hypothesis H1 regarding groups' payoffs:

H1: Aggregate Payoffs

$$\Pi_{eqpay} = \Pi_{propcont} > \Pi_{eqcont} > \Pi_{VCM} = 90.$$

We summarize the theoretical predictions for all contribution schemes in Table 1.

[4] The payoff function of *type40* players is not monotonically increasing in Q^{min}. Therefore, depending on their beliefs about the other players' proposals, the best response of *type40* players is to propose $Q_{type40}^{min} = 0$ or $Q_{type40}^{min} = E$. We assume *type40* players to anticipate the weakly dominant strategies of their group members and since their payoff is maximized by $Q_{type40}^{min} = E$ then, we expect *type40* players to propose full contributions.

Table 1 Theoretical predictions according to standard preferences

	Q^{min}	q_{type20}	q_{type30}	q_{type40}	π_{type20}	π_{type30}	π_{type40}	Π
VCM	0	0	0	0	20	30	40	90
eqcont	78	20	29	29	46.8	47.8	57.8	152.4
eqpay	90	20	30	40	54	54	54	162
propcont	90	20	30	40	54	54	54	162

Q^{min} binding minimum group contribution level; q_{type20} (q_{type30}) (q_{type40}) contribution of *type20* (*type30*) (*type40*) players; π_{type20} (π_{type30}) (π_{type40}) payoff of *type20* (*type30*) (*type40*) players; Π group payoff. For the derivation of the predictions, see Sect. 3.1

Table 2 Experimental design

	Voting	Contribution Scheme	Phases	No. of subjects (No. of groups)
Single-Phase Game	–	*VCM*	Contribution	45 (15)
	–	*eqpay*	Contribution	45 (15)
	–	*eqcont*	Contribution	45 (15)
	–	*propcont*	Contribution	48 (16)
Multi-Phase Game	Majority	*VCM, eqpay, eqcont, or propcont*	Collective-choice and contribution	87 (29)
	Unanimity	*VCM, eqpay, eqcont, or propcont*	Collective-choice and contribution	93 (31)

3.2 Multi-Phase Game

In the first stage of the *Multi-Phase Game*, the collective-choice phase, subjects anonymously vote for one of the proposed rule-based contribution schemes (*eqcont*, *eqpay* and *propcont*). We investigate two different voting mechanisms, namely majority and unanimity rule voting, each comprising three rounds of voting. After each round of voting, all group members are informed about the voting behavior of their group members and on whether an agreement was reached. In order to adopt an agreement, a rule-based contribution scheme has to receive 2 out of 3 votes (majority rule voting) or 3 out of 3 votes (unanimity rule voting). If the sufficient majority is obtained, the corresponding burden sharing rule is subsequently implemented in all periods of the contribution phase. In each period of the contribution phase, all players have to suggest a minimum group provision level. The corresponding costs are distributed among the members according to the burden sharing rule chosen in the collective-choice phase. If a majority cannot be obtained in the collective-choice phase, participants play the *VCM*. We summarize our experimental design in Table 2.

According to standard preferences, we expect *type20* and *type30* players to vote for the *eqpay* and *propcont* schemes more frequently when compared to the *eqcont* scheme. This can be explained by their expected payoffs which are comparatively higher in the *eqpay* and *propcont* schemes (see Table 1). In contrast, for *type40* players, the highest expected payoff appears in the *eqcont* scheme. Therefore, we expect *type40* players to vote for the

eqcont scheme more frequently when compared to the *eqpay* and *propcont* scheme, at least under majority voting. Even though the highest expected payoff for *type40* players can be obtained under the *eqcont* scheme, where these players determine the minimum contribution level ($Q^{min}_{type40} = Q^{min} = 78$), *type40* players may adjust their voting behavior and more frequently opt for an *eqpay* or *propcont* scheme which are clearly preferred by *type20* and *type30* players in order to avoid ending up in a *VCM*. Since the *VCM* is expected to be payoff-dominated by all rule-based contribution schemes, we expect participants to prefer any rule-based contribution scheme over a *VCM* and that subjects try to agree upon a joint burden sharing agreement.[5] Furthermore, we expect an agreement to be more easily achieved under majority than under unanimity rule voting, and that groups agree on the *eqpay* and *propcont* schemes more frequently compared to *eqcont*. This has a simple statistical reason. Assuming that individuals make a random choice, the probability of reaching an agreement after three periods would amount to 0.99 under majority and to 0.30 under anonymity. However, in case players vote according to their standard preferences, the clear dominance of the majority rule in terms of agreement formation might be counteracted if *type40* players under unanimity vote more frequently for the *eqpay* or *propcont* rules, which are also preferred by *type20* or *type30* players.

By relaxing the assumptions of standard preferences and allowing for other-regarding preferences, it can be expected that *type40* players also vote for the *eqpay* scheme. One prominent theory of other-regarding preferences, which also allows simple utility calculations, is the inequality version model by Fehr and Schmidt (1999, F&S). They formalize the idea of inequality aversion by adding a disutility from disadvantageous inequality (weighted by parameter α_i) and a disutility from advantageous inequality (weighted by parameter β_i) to a standard linear utility function. F&S themselves present the mean values $\bar{\beta} = 0.315$ and $\bar{\alpha} = 0.85$ for the inequality aversion parameters, which they both derive from individual behavior in ultimatum games. Blanco et al. (2011) use modified ultimatum and dictator games in order to obtain similar inequality aversion parameters. In their distribution ($n = 61$), 56 % of all subjects can be characterized by $\beta_i > 0.5$, and 33 % of the participants have $\beta_i > 0.67$. In our case, for $\beta_i > 0.67$, a *type40* player prefers *eqpay* over the alternative burden sharing rules. For *type30* and *type40* players with $\beta_i \geq 0$ and $\alpha_i \geq 0$, *eqpay* at least weakly dominates the alternatives.[6] Therefore, we can summarize our expectations in the following hypothesis:

H2: Voting in the Collective-Choice Phase of the *Multi-Phase Game*

(a) According to standard preferences, *type20* and *type30* participants vote for the *eqpay* and *propcont* schemes more frequently than for the *eqcont* scheme. In contrast, *type40* players vote for the *eqcont* scheme more frequently.
(b) Participants prefer any rule-based contribution scheme to a *VCM* and therefore shall try to reach an agreement. They agree on the *eqpay* or *propcont* scheme more frequently than on the *eqcont* scheme, and an agreement is more frequently observed under majority than under unanimity rule voting.
(c) By allowing for other-regarding preferences, it can be expected that *type40* players vote for the *eqpay* scheme more frequently than for the *eqcont* and *propcont* schemes.

[5] In a situation where *type20* and *type30* players suggest *eqpay* under unanimity voting, the *VCM* might emerge as an equilibrium if *type40* players do not expect the two other types to follow their weakly dominant strategies. Consequently, the best response of *type40* players is to propose $Q^{min}_{type40} = 0$, which corresponds to the *VCM*.

[6] See Supplementary Material Section 2 for a detailed description and a graphical illustration.

Furthermore, in our experiment, the collective-choice institution itself becomes a treatment variable for distinguishing whether a contribution scheme is implemented exogenously by the experimenter or endogenously by the voting of the subjects. In order to distinguish between exogenously and endogenously implemented contribution schemes, we add the prefix *ex-* (i.e., *ex-VCM*, *ex-eqcont*, *ex-eqpay* and *ex-propcont*) for the exogenous case and the prefix *end-* (i.e., *end-VCM*, *end-eqcont*, *end-eqpay* and *end-propcont*) for the endogenous case. From a standard theoretical point of view, there should be no difference in the behavior in exogenously and endogenously implemented contribution schemes. But as already discussed in the literature review in Sect. 2, previous experimental studies have shown that the choice of an institutional setting itself has a positive effect on the level of cooperation in social dilemma situations. One argument for the *endogeneity premium* is that there is a limited ability to signal cooperative behavior in social dilemma situations in absence of an endogenous institution formation. Recent experimental findings by Isaac and Norton (2013) suggest that groups voluntarily implement a costly commitment advice for contributing to a public good after having failed to build initial trust in an initial *VCM* setting. We are interested whether the endogeneity premium persists in endogenously determined burden sharing mechanisms. In order to disentangle these alternative predictions, our hypothesis H3 is as follows:

H3: Endogenous and Exogenous Choice of Contribution Schemes

$$\Pi_{ex-i} = \Pi_{end-i} \text{ whereby } i = VCM, eqcont, eqpay, propcont$$

3.3 Laboratory Protocol

The experiment was run in July 2013 at the MaXLab laboratory of the University of Magdeburg in Germany. We used ORSEE (Greiner 2015) for recruiting participants and z-Tree software (Fischbacher 2007) for programming. We recruited 363 students from different disciplines. Each student took part in one of 16 sessions, each one comprising between 21 and 24 subjects. On average, a session lasted about 60 minutes. In each session, we randomly created up to eight groups of three players with different initial endowments. Moreover, each group consisted of one *type20*, *type30* and *type40* player. All players remained in the same group and maintained their type throughout the whole experiment (partner matching). During the collective-choice phase, subjects received information on the type classifications of other players and the outcome of the voting within their group. During the contribution stage, information on individual contributions to the public good, payoffs and corresponding average values within the group were transmitted via screen. Participants were not aware of their exact partners and the experiment did not allow any direct communication between participants.

At the beginning, participants received a set of experimental instructions which included written descriptions, numerical examples, and control questions. Furthermore, participants could make use of a simulator on their screen in order to verify the numerical examples, to answer control questions and to simulate different contribution decisions.[7] A session of the *Single-Phase Game* comprised 12 periods of the public goods game, the first two periods being practice. Additionally, in the *Multi-Phase Game*, the collective-choice phase with a maximum of three voting rounds preceded the public goods game. At the end of each session, one non-practice period of the public goods game was randomly chosen in order to determine individual earnings. The exchange rate between Euro and LD was 1:3. On average, participants earned 14.70 Euro. No additional show-up fee was paid.

[7] We provide the instructions and screenshots in Sections 4 and 5 of the Supplementary Material.

4 Experimental Results

Our experimental design enables us to analyze the performance of different burden sharing rules being endogenously implemented by agents themselves both to an exogenously implemented *VCM* and to a setting where allocation schemes are predetermined by an agenda setter. While agenda setting appears not to be feasible—or at least highly controversial—in many situations, an endogenous institution formation faces the risk of coordination failure, i.e., it includes the risk that an agreement cannot be reached and therefore, that no institutional framework will be implemented at all. Following our main research question, that is to analyze whether efficiency gains from exogenously implemented schemes persist in a setting with institution formation, the sequence discussing our experimental results explicitly focuses on the comparison of payoffs and does not always reflect the order within the experiment. In a first step, we study the voting behavior in the *Multi-Phase Game* (Sect. 4.1). Subsequently, we compare payoffs from endogenously implemented contribution schemes at the aggregate level (i.e., including both groups that either managed to reach an agreement or who failed to agree upon a joint burden sharing rule) to a predetermined *VCM* (Sect. 4.2). We further examine differences in payoff levels in exogenously and endogenously implemented burden sharing schemes. In order to further elaborate potential differences in payoff levels, we additionally discuss individual contribution decisions (Sect. 4.3) and how they are related to minimum group contribution levels (Sect. 4.4).

4.1 Voting Behavior

Observation 1 *Despite expected differences in preferences on how to share the costs of providing a public good the majority of all groups successfully manages to agree upon a common burden sharing rule. Approximately one third of them obtain an agreement already in the first voting round. The equal-payoff scheme is the most frequently chosen burden sharing mechanism. If participants however fail to reach an agreement in the first voting round, they opt for the equal-payoff scheme less frequently, but rather for a proportional contribution scheme in the remaining two voting rounds.*

Analyzing voting behavior in the *Multi-Phase Game* reveals that almost 4 out of 5 groups successfully implement a joint burden sharing scheme (see Table 3). Remarkably, we find that approximately one third of all agreements (21 groups, 35 %) are already established in the first voting round. As expected in hypothesis H2b, a common agreement is more easily obtained under majority (97 %) than under unanimity rule voting (58 %) ($p < 0.01$, χ^2-test and Fisher's exact test).

In accordance with our theoretical prediction formulated in H2b, we indeed find the preferred allocation rule to be dependent on subjects' initial endowments (see Fig. 1). By considering all three rounds of the collective-choice phase, we find that agents do not randomly choose one of the proposed rule-based contribution schemes. Instead, the probability of an agent to opt for the *eqpay* scheme is significantly decreasing in the initial endowment (*type20*: 71 %, *type30*: 46 %, *type40*: 20 %) ($p < 0.01$, Binomial Test). Furthermore, *type40* players vote for the *eqcont* scheme more often than other group members (*type40*: 50 %, *type30*: 12 %, *type20*: 9 %) ($p < 0.01$, Binominal Test). The *propcont* scheme is most frequently chosen by *type30* players (*type40*: 29 %, *type30*: 42 %, *type20*: 20 %) ($p < 0.05$, Binominal Test).

Table 3 Implemented contribution schemes in the *Multi-Phase Game*

	Majority rule voting	Unanimity rule voting	Total
VCM (coordination failure)	1	13	14
	(3.5)	(41.9)	(23.3)
eqcont	3	2	5
	(10.3)	(6.5)	(8.3)
eqpay	18	10	28
	(62.1)	(32.3)	(46.7)
propcont	7	6	13
	(24.1)	(19.4)	(21.7)
Total	29	31	60
	(100)	(100)	(100)

Contribution schemes chosen by a group serve as one observation. If a sufficient majority, two out of three (majority rule voting) or three out of three (unanimity rule voting), cannot be obtained after the third voting round, participants play the *VCM*. Percentage in parentheses

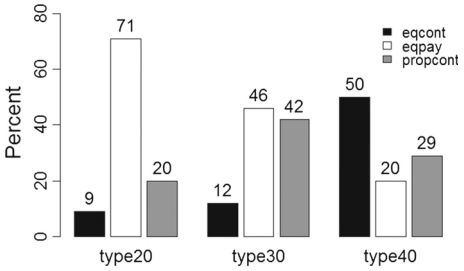

Fig. 1 Individually chosen rule-based contribution schemes. *Notes* Individually chosen rule-based contribution scheme in all three rounds of the collective-choice phase of the *Multi-Phase Game* by types

We find that *eqpay* is the burden sharing rule which is most frequently chosen in a successful agreement, being implemented in nearly half of the cases ($p < 0.01$, Binomial Test). The *propcont* scheme is taken by 22 % and the *eqcont* scheme by 8 % of all groups (see Table 3). 23 % of all groups fail to reach consensus. At first glance, standard theory of rational and selfish behavior performs considerably well when looking at subjects' voting behaviors. However, the dominance of the *eqpay* scheme, emerging in 62 % of all cases under majority voting and still in 32 % under unanimity voting, cannot be explained by standard theory but may rather coincide with other-regarding preferences. In particular, as indicated in H2c, the decision behavior of *type40* players opting for *eqpay* may be driven by inequality aversion (e.g., F&S). If we assume that players prefer a burden sharing rule being at least at one minimum group contribution level payoff dominant and that players try to directly reduce inequality by implementing binding minimum contribution levels, i.e., not by implementing

voluntary contributions exceeding the binding minimum contribution level, *type40* players prefer the *eqpay* to the *eqcont* as well as the *propcont* schemes for a sufficiently high level of disutility from advantageous inequality.[8]

Coordination failure could either reflect divergent preferences or, since direct communication was not allowed, a coordination problem, meaning that group members are per se willing to form an agreement but simply fail to vote for a certain burden sharing rule at the same time so that the required majority is not obtained. We find that agents change their voting behavior in case they fail to reach an agreement in the first round of the collective-choice phase. Especially under unanimity voting, *type20* players vote for the *eqpay* scheme less frequently and thus, more frequently for *propcont*. As discussed in our theoretical predictions, *type40* players seem to adjust their voting behavior under unanimity over time. While 61 % of these players vote for the *eqcont* scheme in the first round, this share drops to 24 % in the third round and the *propcont* scheme is selected in most cases by these types (57 % of the votes). We do not observe this adjustment under majority voting.[9] One possible explanation is that *type40* players become aware of their pivotal positon under unanimity and accordingly adjust their voting behavior after the first round in order to avoid ending up in a *VCM*.

4.2 Payoffs

Observation 2 *Average payoffs under endogenous institution formation at an aggregate level (end-all), i.e., including those groups that did not reach an agreement, are higher than in a predetermined VCM in the last five periods. Compared to the benefits from the exogenously imposed burden sharing rules, endogenous institutions reveal similar payoffs at an aggregate level.*

Across all periods, average aggregated payoffs (in LD) for all groups who take part in the *Multi-Phase Game*, including those groups who fail to reach an agreement, *(end-all)*, amount to 46.6 LD (Table 4; Fig. 2). When considering all periods of the contribution phase, average payoff levels are not statistically different between the groups who take part in the *Multi-Phase Game* and those who participate in the exogenously implemented *VCM* (*end-all*: 46.6, *ex-VCM*: 44.0, $p = 0.128$, Mann-Whitney U (MW-U) test). If we give groups more time for coordination and only consider the last five periods, the difference between the *Multi-Phase Game* (*end-all*: 46.9) and *ex-VCM* (41.8) becomes more pronounced and significant ($p < 0.05$, MW-U test). Moreover, aggregated payoffs under an endogenously induced institution formation (*end-all*) resemble the benefits from the different burden sharing rules obtained in the *Single-Phase Game* (*ex-eqcont*: 47.0, *ex-eqpay*: 47.2, *ex-propcont:* 49.4).

Thus, enabling an endogenous institution formation on a joint burden sharing agreement is preferable to a situation where contributions to the public good are provided in a decentralized manner (ex-*VCM*). Moreover, institution formation is equally preferred to externally determined burden sharing rules. This latter observation may be driven by two important behavioral responses to the voting mechanism in our experiment. As discussed in Sect. 4.1,

[8] See Supplementary Material in Section 2 for a graphical illustration. We are aware that inequality might also be indirectly reduced by voluntarily exceeding the required individual minimum level. For instance, *type40* players might have an incentive to contribute more than required in order to reduce inequality. Anticipating this, *type20* and *type30* players might have an incentive to reduce the binding minimum contribution order to free ride on the voluntary contributions of the *type40* player. However, we focus on the case where players try to directly reduce inequality by implementing a binding minimum contribution level.

[9] See Supplementary Material Section 3 for a detailed graphical illustration of the voting behavior in the respective rounds of the collective-choice phase of the *Multi-Phase Game*, either under majority or under unanimity rule voting.

Table 4 Summary statistic—payoffs and contributions

	end-all	*ex-VCM*	*end-VCM*	*ex-eqcont*	*end-eqcont*	*ex-eqpay*	*end-eqpay*	*ex-propcont*	*end-propcont*
All periods									
π_{all}	46.60	43.96	36.51	46.96	46.26	47.16	51.05	49.43	47.99
π_{type20}	43.18	32.27	27.91	41.44	40.85	45.02	50.30	47.15	45.19
π_{type30}	46.16	43.65	34.46	46.25	45.24	47.30	51.33	49.52	47.97
π_{type40}	50.45	49.95	47.17	53.20	52.70	49.17	51.53	51.63	50.79
q_{all}	20.75	17.45	8.14	21.20	20.33	21.45	26.32	24.29	22.48
q_{type20}	14.16	13.13	6.74	16.73	15.74	13.60	17.07	16.58	15.27
q_{type30}	21.18	17.75	10.20	21.91	21.35	21.31	26.04	24.21	22.49
q_{type40}	26.89	21.46	7.49	24.96	23.89	29.45	35.84	32.09	29.68
Last five periods									
π_{all}	46.89	41.82	34.81	47.94	46.56	47.28	51.78	49.62	49.43
π_{type20}	43.59	35.75	25.40	42.91	41.45	44.57	51.26	47.46	47.48
π_{type30}	46.64	41.06	33.35	46.74	45.23	47.67	52.24	49.67	49.45
π_{type40}	50.40	48.65	45.68	54.17	52.99	49.61	51.86	51.73	51.35
q_{all}	21.10	14.77	6.01	22.42	20.69	21.60	27.23	24.53	24.28
q_{type20}	14.39	10.84	5.43	17.45	16.00	14.32	17.76	16.69	16.23
q_{type30}	21.33	15.53	7.47	23.62	23.40	21.21	26.78	24.48	24.26
q_{type40}	27.57	17.95	5.14	26.19	25.40	29.28	37.16	32.41	32.35

We plot average payoffs and contributions both for all 10 periods (excluding trial periods) and the last five periods. π_{all} average payoffs per group; π_{type20} (π_{type30}) (π_{type40}) averages payoffs of *type20* (*type30*) (*type40*) players; q_{all} average contributions per group; q_{type20} (q_{type30})(q_{type40}) average contributions of *type20* (*type30*) (*type40*) players. Exogenously implemented contribution schemes get the prefix *ex-* (i.e., *ex-VCM, ex-eqcont, ex-eqpay* and *ex-propcont)*, endogenously implemented contribution schemes get the prefix *end-* (i.e., *end-all, end-VCM, end-eqcont, end-eqpay* and *end-propcont)*

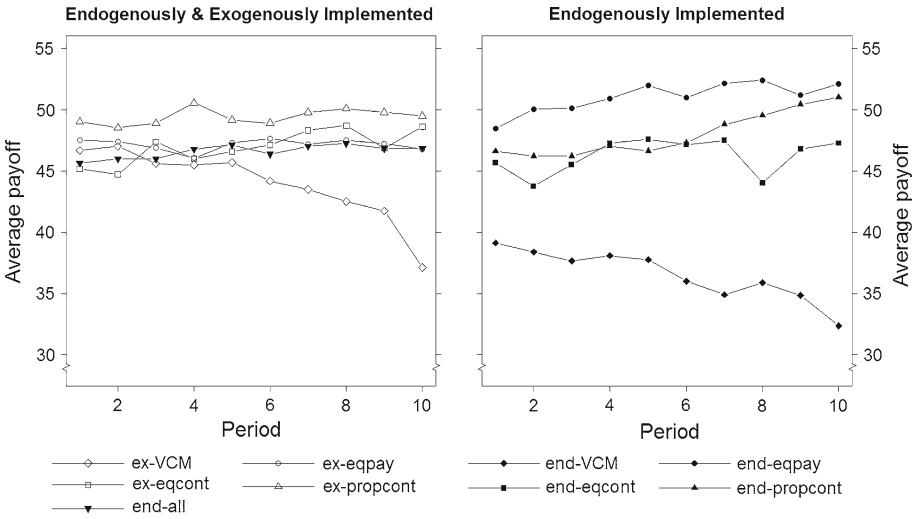

Fig. 2 Average payoff over time. *Notes* Average payoffs in each period (excluding trial periods) of the game serve as one observation. On the left: payoffs in all exogenously implemented contribution schemes separately and the average of all endogenously implemented contribution schemes. On the right: payoffs in all endogenously implemented contribution schemes separately

a broad majority of the groups manages to agree upon a joint distribution rule and individuals on average may simply contribute at similar rates in contrast to the exogenous case. Considering the *endogeneity premium*, we particularly investigate whether efficiency levels from those groups who reach consensus help to outweigh efficiency losses from coordination failure and if these efficiency gains differ across endogenously implemented burden sharing agreements.

We study payoff levels in the different burden sharing schemes, both in the *Single-* and the *Multi-Phase Game*. We first summarize the results of the exogenously implemented contribution schemes and subsequently compare these findings to the agreement formation.

Similar to previous findings on the minimum contribution mechanism (e.g., Kesternich et al. 2014a), group payoffs are higher in rule-based contribution schemes than in the *ex-VCM* (44.0) if they are adopted by an agenda setter (see Table 4). Averaged over all periods and agents, payoffs are highest in the *ex-propcont* setting (49.4). They amount to 47.0 in *ex-eqcont* and to 47.2 in *ex-eqpay*. Our regression analysis reveals that all exogenously implemented burden sharing schemes increase efficiency as opposed to a *ex-VCM* ($p < 0.1$ for *eqpay* and *eqcont*, $p < 0.01$ for *propcont*, Table 5 Model 2).[10] Thus, the observed behavior is at least partly in accordance with hypothesis H1.

In case of an endogenous institution formation, substantial efficiency gains can be realized if the *end-eqpay* scheme (51.1) is implemented. Payoffs are lowest if groups fail to reach a burden sharing agreement and consequently have to play *end-VCM* (36.5) (see Table 4). We find that the average payoffs per group are significantly higher in case one of the three rule-based contribution schemes (*eqcont*, *eqpay* or *propcont*) is adopted than in case none of

[10] A series of random-effects regression models is used in order to determine the payoffs of individuals. The discussion of the results is based on standard errors computed at group level. We consider individual level random effects, i.e., one observation of one individual corresponds to the panel variable and the period defines the time variable. All in all, our econometric analysis comprises 3630 observations. Due to missing sociodemographic information, we had to remove three out of the 366 participants from our economic analysis. Regarding the remaining 363 subjects, we have one observation for each of the 10 payoff-relevant periods.

Table 5 Random-effects regression of payoffs per subject

	1	2	3	4	5	6	7	8
	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}
Contribution Scheme	all	all	all	*all*	*VCM*	*eqcont*	*eqpay*	*propcont*
Implementation	end	end	ex	ex	end & ex	end & ex	end & ex	end & ex
eqpay	14.09***	16.72***	3.53	2.79				
	(1.61)	(2.66)	(2.67)	(3.71)				
eqcont	9.09**	8.69	3.25	−3.34				
	(3.96)	(5.47)	(2.44)	(4.03)				
propcont	11.28***	10.97**	5.51**	4.05				
	(2.40)	(4.29)	(2.60)	(4.12)				
voting					−7.38***	−1.67	3.43*	−1.47
					(2.59)	(4.00)	(1.86)	(2.49)
period	0.14	−0.64***	−0.10	−0.88***	−0.77***	0.32**	0.22	0.30**
	(0.10)	(0.12)	(0.13)	(0.17)	(0.11)	(0.13)	(0.15)	(0.15)
eqpay × period		0.97***		0.88**				
		(0.18)		(0.37)				
eqcont × period		0.81***		1.25***				
		(0.19)		(0.24)				
propcont × period		1.20***		0.98***				
		(0.24)		(0.25)				
type30	3.13***	7.14***	3.90***	6.00***	6.01***	4.01***	1.78***	2.02**
	(0.75)	(2.25)	(0.66)	(1.56)	(1.48)	(1.06)	(0.65)	(0.93)
type40	7.38***	19.24***	7.84***	11.93***	15.32***	11.56***	2.35***	4.59***
	(1.15)	(1.64)	(1.12)	(2.83)	(1.72)	(1.33)	(0.68)	(1.38)
eqpay × type30		−5.95***		−3.37*				
		(2.26)		(1.88)				
eqpay × type40		−17.55***		−8.66***				
		(1.87)		(3.11)				
eqcont × type30		−3.26		−1.03				
		(3.01)		(1.81)				
eqcont × type40		−8.33**		0.41				
		(3.39)		(3.11)				
propcont × type30		−4.71*		−3.74*				
		(2.55)		(1.93)				
propcont × type40		−13.92***		−8.05**				
		(2.47)		(3.40)				
male	2.45**	1.63	1.30	1.73	0.37	2.36	1.82**	2.38
	(1.13)	(1.11)	(1.15)	(1.18)	(2.28)	(1.51)	(0.89)	(1.64)
exp	−0.03	−0.02	0.14*	0.17**	−0.03	0.10	0.11*	0.09
	(0.07)	(0.07)	(0.07)	(0.07)	(0.12)	(0.12)	(0.06)	(0.11)

Table 5 continued

	1	2	3	4	5	6	7	8
	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}	π_{it}
Contribution Scheme	all	all	all	*all*	*VCM*	*eqcont*	*eqpay*	*propcont*
Implementation	end	end	ex	ex	end & ex	end & ex	end & ex	end & ex
Constant	31.52***	30.72***	38.54***	40.20***	41.16***	38.02***	42.74***	43.45***
	(1.93)	(2.34)	(2.53)	(3.41)	(3.34)	(2.53)	(2.04)	(2.47)
Observations	1800	1800	1830	1830	870	600	1290	870
Number of Groups	180	180	183	183	87	60	129	87

Standard errors in parentheses, adjusted for group clusters: $^{*}p < 0.1$, $^{**}p < 0.05$ and $^{***}p < 0.01$. π_{it} individual payoff of subject i in each period (excluding the trial periods); eqcont (eqpay, propcont) = 1 if subject i played *eqcont (eqpay, propcont)*, 0 else; voting = 1 if subject i played the *Multi-Phase Game*, 0 else; period = period of contribution phase; type30 (type40) = 1 if subject i is *type30* (*type40*), 0 else; male = 1 if subject i is male, 0 if female; exp = number of experiments subject i has taken part in MaXLab. Model 1 and Model 2 consider observations from all endogenously implemented contribution schemes (*end-VCM, end-eqcont, end-eqpay, and end-propcont*). Model 3 and Model 4 consider all observations from exogenously implemented contribution schemes (*ex-VCM, ex-eqcont, ex-eqpay, and ex-propcont*). Model 5 considers observations from the endogenously and exogenously implemented *VCM* (*end-VCM and ex-VCM*). Model 6 considers observations from the endogenously and exogenously implemented *eqcont (end-eqcont* and *ex-eqcont)*. Model 7 considers observations from the endogenously and exogenously implemented *eqpay (end-eqpay* and *ex-eqpay)*. Model 8 considers observations from the endogenously and exogenously implemented *propcont (end-propcont* and *ex-propcont)*

the schemes does receive a sufficient majority ($p < 0.05$, MW-U Test, last five periods and Table 5, Model 1). Furthermore, our regression analysis reveals that payoffs in endogenously implemented contribution schemes show different trends over time, depending on the contribution scheme implemented. We find decreasing payoffs in case coordination upon a joint burden sharing scheme has failed. In contrast, if one of the three proposed burden sharing rules is endogenously implemented, we observe positive trends over periods (Table 5, Model 2). In addition, we find that *type40* and *type30* players receive significantly higher payoffs than *type20* players in all contribution schemes, either endogenously or exogenously implemented. However, these differences in payoffs are particularly pronounced in the *VCM*, and they are reduced in case a burden sharing rule is implemented (Table 5, Model 2 and 4).

Observation 3 *Average payoffs in an equal-payoff scheme are higher if this scheme is implemented by voting compared to a situation where it is exogenously implemented. If no consensus on a joint distribution rule is reached and agents end up in an uncoordinated action, they earn less than in the exogenously implemented VCM.*

An endogenous institution formation affects payoff levels in the different burden sharing schemes. If participants decide to implement the *eqpay* scheme, payoffs are significantly higher than in the exogenously implemented counterpart ($p < 0.05$, MW-U Test). With respect to the *eqcont* and *propcont* schemes, we cannot confirm that endogenously implemented institutions have an impact on efficiency levels. In contrast, we find that payoffs are significantly lower if no consensus is reached and players end up in an uncoordinated action than in a *VCM* being exogenously implemented ($p < 0.05$, MW-U Test). Thus, hypothesis H3 has to be rejected. This observation emphasizes the risk of negotiation failures. The results of our regression analysis repeatedly confirm these findings (see Table 5, Model 3 and 5).

It could be argued that the differences in payoff levels between endogenously and exogenously implemented contribution schemes are driven by a sample selection effect described by Dal Bó et al. (2010). They show that cooperative subjects are selected from uncooperative participants in the collective-choice phase. We do not deny a possible sample selection effect but according to this argument, a sample selection effect should be relatively weak if groups already agreed on a common allocation rule in the first round of the collective-choice phase. By considering solely these groups and by focusing on the *eqpay* scheme, we find that voting still has a positive impact on payoff levels. Average payoffs in groups that agree on the *eqpay* scheme in the first voting round amount to 50.4 and are higher than in the exogenously implemented *eqpay* scheme (47.2). In this sense, we argue that our results are in line with the existing literature on the endogeneity premium and that they are at least partly driven by an effect of the endogenous choice rather than solely by a sample selection effect.

Observation 4 *If an agenda setter determines the distribution rule exogenously, an allocation rule requesting proportional contributions from the different types of players leads to the highest average payoff per group across all periods and at least weakly payoff-dominates all other burden sharing rules. In case of an endogenous institution formation, groups benefit most if they agree upon an equal-payoff scheme.*

The allocation schemes clearly differ in the distribution of their benefits among the different players. Nevertheless, there is evidence that in case of exogenously implemented contribution schemes, the *propcont* scheme at least weakly payoff-dominates all other contribution schemes. Compared to the other contribution schemes, *type20* (47.2) and *type30* (49.5) players receive their highest payoff in *ex-propcont*. Even though *type40* players earn the most across all periods if all players have to contribute the same amount (53.2), this is not statistically different from their payoff in the *ex-propcont* scheme (51.6).

Considering the endogenously implemented contribution schemes, the analysis reveals a different picture: The *eqpay* scheme leads to the highest average payoffs but is not payoff-dominant compared to the other contribution schemes. In addition, *type20* (50.3) and *type30* players (51.3) receive their highest payoff in *eqpay* compared to all other schemes. Once again, *type40* (52.7) players benefit most in the *eqcont* scheme. The difference between *eqcont* and *eqpay* (51.5) is significant for *type40* players ($p < 0.1$, MW-U Test).

4.3 Contributions

In this part, we focus on contribution behavior in order to explore the differences in payoff levels in more detail. Figure 3 reports average group contribution levels for each either endogenously or exogenously implemented contribution scheme.

In the *Single-Phase Game*, if we focus on the last five periods, the contributions to the public good of all types of different players are higher in all burden sharing schemes than in the *VCM* (see Table 4). As already discussed in the previous section, *ex-propcont* achieves the highest efficiency gains resulting from the highest average contributions (24.3). In this scheme, contributions from both *type30* (24.2) and *type40* players (32.1) are higher than in all other schemes. The contributions of *type20* players in *ex-propcont* (16.6) exceed those in *ex-eqpay* (13.6) but are lower than in *ex-eqcont* (17.5). In the exogenous case, welfare gains in the *ex-propcont* scheme are particularly driven by increases in contributions from *type30* and *type40* players. How are these findings related to the observations from endogenous institution formation? *propcont* achieves similar average contribution levels in the *Single-*

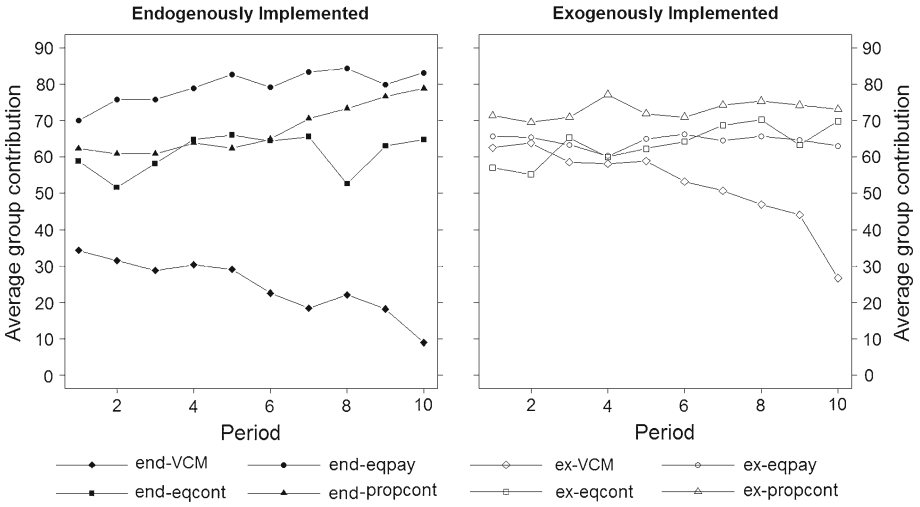

Fig. 3 Average group contribution over time. *Notes* Average group contribution in each period (excluding the trial periods) of the game serve as one observation. On the left (right): contributions in the endogenously (exogenously) implemented contribution schemes

and in the *Multi-Phase Game* (24.3 vs. 22.5). This also applies to the *eqcont* scheme (21.2 vs. 20.3). In contrast, average contribution levels increase in the *eqpay* scheme (21.5 vs. 26.3) and collapse in the *VCM* (17.5 vs. 8.1). In *eqpay*, all types of players contribute more to the public good than in the exogenous case if they agree upon this distribution rule. Moreover, total contributions are higher than in any other endogenously implemented burden sharing scheme.

4.4 Minimum Group Contribution Levels

We now examine binding minimum group contribution levels (see Fig. 4; Table 6) and individual minimum proposals in order to explore the voting effect of the *eqpay* scheme. As indicated by the contribution behavior of participants and their corresponding payoffs, we find that the average binding minimum group contribution level is higher in case the *eqpay* scheme is endogenously implemented (76.6) than in case the same scheme is exogenously implemented (61.4) ($p < 0.1$, MW-U Test). In contrast, for *propcont*, we find that binding minimum group contribution levels tend to be higher if the rule is exogenously imposed (69.5 vs. 66.7). By focusing on groups who failed to coordinate at the entire contribution level, we find that *type40* players predominantly set the binding minimum group contribution level in *eqpay* (*ex-eqpay*: 41.8 %, *end-eqpay*: 50.6 %). More precisely, we find that *type40* players make the smallest proposals for the binding minimum group contribution level on average, independent from the method of implementation. In case the *eqpay* scheme is chosen in the collective-choice phase, they propose a binding contribution level of 81.2 on average. In case the scheme is implemented exogenously, they propose a contribution level which amounts to 73.9 on average. Moreover, *type30* players suggest an average binding contribution level of 83.6 in the endogenously implemented and 77.2 in the exogenously implemented case; *type20* players suggest amounts of 85.7 and 77.9, respectively. All types of players increase their average proposals in case the *eqpay* scheme is endogenously determined by contrast with the exogenously implemented *eqpay* scheme. In contrast, when looking at *propcont*,

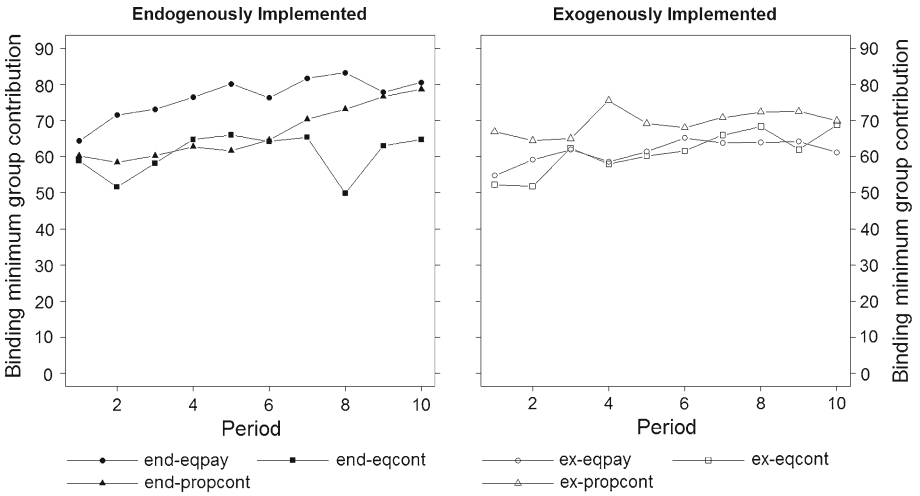

Fig. 4 Average binding minimum group contribution level over time. *Notes* Average binding group minimum contribution levels in each period (excluding the trial periods) of the game serve as one observation. On the left (right): contributions in the endogenously (exogenously) implemented contribution schemes

Table 6 Summary statistic—binding group minimum contribution levels

	ex-eqcont	*end-eqcont*	*ex-eqpay*	*end-eqpay*	*ex-propcont*	*end-propcont*
All periods						
Q^{min}	61.14	60.66	61.44	76.55	69.51	66.67
q^{min}_{type20}	16.57	15.46	12.03	16.04	15.45	14.82
q^{min}_{type30}	21.25	21.31	20.31	25.39	23.17	22.22
q^{min}_{type40}	23.32	23.89	29.10	35.12	30.89	29.63
Last five periods						
Q^{min}	64.5	62.20	63.30	79.98	70.50	70.85
q^{min}_{type20}	17.24	15.37	13.12	17.06	15.67	15.74
q^{min}_{type30}	22.57	22.12	20.89	26.55	23.50	23.62
q^{min}_{type40}	24.68	24.71	29.29	36.38	31.33	33.49

We plot average payoffs and contributions both for all 10 periods (excluding trial periods) and the last five periods. Q^{min} average binding minimum group contribution levels; $q^{min}_{\text{type20}}(q^{min}_{\text{type30}})(q^{min}_{\text{type40}})$ average binding contribution levels of *type20* (*type30*) (*type40*) players. Exogenously implemented contribution schemes get the prefix *ex-* (i.e., *ex-VCM, ex-eqcont, ex-eqpay and ex-propcont*), endogenously implemented contribution schemes get the prefix *end-* (i.e., *end-VCM, end-eqcont, end-eqpay* and *end-propcont)*

minimum contribution proposals are about five LD lower from each type of player under voting compared to the situation where an agenda setter implements the distribution rule. In addition, *type40* players propose a binding minimum contribution level of 73.6 on average (79.1 in *ex-propcont*), *type30* players suggest 77.1 (82.9 in *ex-propcont*) and *type20* players 74.2 (79.7 in *ex-propcont*). There is one speculative explanation for this observation, stating that groups need more time for coordination in the endogenously implemented *propcont* scheme. If groups agree on an *eqpay* scheme, binding group contribution levels

tend to increase immediately from the first period onwards. In contrast, when looking at the endogenously implemented *propcont* rule, group contribution levels are lower compared to *end-eqpay*. They remain rather constant in the first five periods, start to increase from the sixth period onwards and exceed group contribution levels determined by the exogenously implemented *propcont* rule only in the second half of the contribution phase (see Fig. 4).

One possible explanation could be that groups in the endogenously implemented *propcont* scheme are comparatively heterogeneous with respect to their preferred burden sharing rule. This occurs since the *propcont* scheme is most frequently implemented if coordination in the first rounds of the collective-choice phase fails. In this sense, we argue that the heterogeneity of groups in the endogenously implemented *propcont* scheme limits cooperation gains—at least in the first half of the contribution phase where players act rather cautious in order to learn more about their group members.

5 Summary and Concluding Remarks

In this experiment, we investigate whether the endogenous choice of different rules on how to share the costs of providing a public good affects individual contribution behavior. While agenda setting appears not to be feasible—or at least highly controversial—in many situations, endogenous institution formation faces the risk of coordination failure. At the aggregate level, i.e., including both groups that reach consensus upon a joint burden sharing rule and groups that fail to agree upon a common scheme, our results show that those participants who face a voting decision receive, on average, higher payoffs than participants in an exogenously implemented *VCM*. Moreover, they do not earn less than participants in any externally implemented burden sharing rule. This is driven by two important results. At first, despite different preferences for how to share the costs of providing a public good among heterogeneous agents, we find that groups manage to agree upon a common burden sharing rule in most cases. Second, endogenously and exogenously implemented rule-based contribution schemes are effective in increasing the level of contributions to the public good. While we observe this positive effect of an endogenous institutional choice on contributions to the public good, there is also a negative effect. If group members fail to agree upon a rule-based contribution scheme in the collective-choice phase of the *Multi-Phase Game*, they have to play the *VCM*. In this endogenously implemented case, contributions are lower than in case the *VCM* is exogenously implemented. The positive effect from the choice of institutions is, nevertheless, in line with the existing literature which points out (weak) evidence for enhancing cooperation through voting. Regarding the endogenously implemented *VCM*, one can speculate that group members are disappointed about the outcome of the election and behave accordingly uncooperative. Nevertheless, the low contribution levels in this scheme may also be driven by a sample selection effect induced by the collective-choice phase of the *Multi-Phase Game*. In our experimental design, we cannot exclude that the endogenously implemented *VCM* "collects" all uncooperative participants who failed to implement a common rule-based contribution scheme.

Therefore, our results indicate that an endogenously induced formation on a joint burden sharing agreement offers both chances and risks, depending on whether or not an agreement is reached. However, our results show that institution formation does not harm overall payoffs at the aggregated level. In particular, average payoffs are higher if agents face the opportunity to agree upon a joint burden sharing rule compared to an uncoordinated action. This observation

may reveal interesting conclusions for a local agenda-setter as it shows that the benefits of the choice between different appropriate designed burden sharing rules do outweigh the risks.

As a matter of course, this implication has to be treated with caution because our experimental design shows at least one limitation since it automatically enforces the binding minimum contribution levels. Therefore, our design does not take into account that sovereign agents may deviate from initially accepted contribution patterns. However, any burden sharing mechanism in our experimental design only implements provision levels that all players have agreed upon previously. In addition, in the *Multi-Phase Game*, players perceiving to be "overruled" by their group members are always able to block any further cooperation by suggesting low minimum group contribution levels to the public good. The lowest common denominator principle therefore ensures that all subjects have veto power. Moreover, the perception on what constitutes a fair burden sharing norm may differ across countries and societies. Whether our results can be transferred to subjects with different cultural backgrounds remains an open question and deserves further research. In addition, to bring our experimental design closer to international negotiations with many players being involved, larger group sizes with players of different types might be taken into account in future research. Furthermore, one potentially meaningful extension would be to relax the assumption that all agents are fully informed about the cost and benefits from investing into the public good, i.e., the voting procedure could take place behind a "veil of ignorance" (Rawls 1971).

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