Allocating a Voluntarily Provided Common-Property Resource: 
An Experimental Examination*

Brock Stoddard†
Department of Economics
University of South Dakota, USA

James M. Walker
Department of Economics
Vincent and Elinor Ostrom Workshop in Political Theory and Policy Analysis
Indiana University, USA

Arlington Williams
Department of Economics
Indiana University, USA

Abstract: This paper examines a voluntarily provided common-property resource (CPR) in settings that vary the rules used for allocating the resource to providers. Three allocation mechanisms are investigated: “allocator,” “tremble,” and “egalitarian.” The allocator mechanism, based on institutions observed in the field, is the primary mechanism of interest. In this treatment condition, one person in a group is exogenously chosen to allocate shares of the CPR to other group members. After observing group members' provision decisions, the allocator chooses shares of the CPR to allocate to each group member. The other two mechanisms serve as controls for examining the extent to which the allocator mechanism affects provision of the CPR. The tremble mechanism randomly divides the CPR between group members using the same division rules as the allocator mechanism. The egalitarian mechanism divides the CPR equally between group members. Provision of the CPR does not decay over time and is significantly closer to the group's socially optimal level under the allocator mechanism than under the tremble and egalitarian mechanisms. From a policy perspective, these results suggest that utilizing institutions such as the allocator mechanism in the field can facilitate greater levels of cooperation in promoting the provision of shared resources.

Keywords: common pool resources; provision, cooperation; allocation mechanisms, laboratory experiments

JEL codes: D7; D3; H4; C90

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† Corresponding author: Department of Economics, University of South Dakota, 414 E Clark Street, Vermillion, South Dakota, 57069; Email: brock.stoddard@usd.edu, Phone: (605)-677-6643
1. INTRODUCTION

A growing experimental literature on asymmetric power in social-dilemma settings indicates that giving one person informational and/or decision-making advantages significantly impacts a group’s voluntary provision of a public good (Guth et al. 2007, Norton and Isaac 2010, Hamman et al. 2011, and Cox et al. 2013). This paper investigates an allocator mechanism where one person in a group, the allocator, has the power to divide a voluntarily provided common-property resource (CPR) between the other members of the group. After observing group members’ provision decisions, the allocator chooses one of three exogenously provided division rules that stipulate the share of the CPR to be allocated to each group member. Behavior observed using the allocator mechanism is contrasted with that observed in two additional mechanisms, the egalitarian and tremble mechanisms.\(^1\) The allocator mechanism investigated here differs from the egalitarian and tremble mechanisms in that asymmetric power is given to the allocator to divide the resource between group members after observing their provision decisions.

Motivation for this study comes from the mechanisms used by many non-profit organizations with multiple branches, where a central authority determines how to allocate its resources between branches of the organization. For example, the Sierra Club, a national environmental organization, allocates resources to its state-level chapters by following a determined “subvention formula.”\(^2\) Interestingly, discussion of similar mechanisms can be found in Acts 5 in the Bible. Early Christians contributed all their property to the Apostles who then allocated the property within the Church. In the 19th century, religious and utopian groups along the American frontier implemented this practice with the goals of, among other things, alleviating poverty and increasing the group’s overall wealth through cooperation (Bushman 2007). One group, the Mormons, assigned a Bishop to allocate the consecrated property among the community (Arrington 1976). The Bishop had private information about members’ needs and production capabilities that enabled him to allocate property to best reach the goals of the community.\(^3\) In the late 19th century the mainstream Mormon Church, or Church of Jesus Christ of Latter-day Saints (LDS), transitioned away from this system (Warner 1888, Gardner 1917, and 1922). However, communities in the Fundamentalist Church of Jesus Christ of Latter-day Saints (FLDS) still practice this system.

In this study, the allocator mechanism is examined in a setting in which subjects make repeated decisions, learning about others’ actions across decision rounds. In a linear decision setting, voluntary provision of a CPR is contrasted across three treatments: provision-allocator, provision-tremble, and provision-egalitarian. The tremble mechanism randomly divides the CPR between group members using

\(^{1}\) Other allocation mechanisms are examined in social-dilemma settings involving inter-group contests and collective-group rent seeking. For theoretical studies see Lee 1995, and Rapoport and Amaldoss 1997. In experimental studies, competing groups or teams facing intra-group collective action problems increase their chances of winning a prize by increasing their provision of a group fund (Rapoport and Bornstein 1989, Nalbantian and Schotter 1997). The winning group shares the prize according to an allocation mechanism. Also, see Gunnthorsdottir & Rapoport 2006. Both empirical and theoretical studies show that provisions to a group fund are closest to the group’s socially-optimal level under proportional mechanisms rather than under the egalitarian mechanism.

\(^{2}\) This information was obtained through co-author Stoddard’s personal emails with the Sierra Club, as well as through conversations with Matthew Baggetta, assistant professor in the School of Public and Environmental Affairs at Indiana University.

\(^{3}\) Section 51 in the Doctrine and Covenants, a book of canonical Mormon scripture, instructs the first Mormon Bishop in his responsibilities.
the same exogenous division rules as with the allocator mechanism. The egalitarian mechanism divides the CPR evenly between group members. The experimental data reveal that CPR provision is significantly closer to the group’s socially-optimal level under the allocator mechanism than under the tremble and egalitarian mechanisms. This result suggests that, in the field, institutions with properties similar to the allocator mechanism can play an important role in enhancing cooperation and efficiency in collective-choice settings that promote the provision of shared resources.

Unlike this study’s focus on allocating a voluntarily-provided CPR, most classical experimental CPR studies focus on appropriation from exogenously provided CPRs (e.g. Ostrom et al. 1992, and Holt et al. 2012) and endogenously provided CPRs (Janssen et al. 2011). The paper is more closely related to the public-goods literature, in particular, public-goods studies with asymmetric power given to an individual group member. 4 Guth et al. (2007) examined the role of leadership where one randomly chosen group member had power to exclude one member from the group in the next round after observing each member’s provision decision. Rivas and Sutter (2009) further examined the role of leadership by comparing an exclusion-power setting, as in Guth et al. (2007), to a setting where one randomly chosen group member had power to “reward” another group member with higher earnings after observing each member’s provision decision. Assigning a reward lowered the earnings of the leader and the other group members who did not receive the reward. In both Guth et al. (2007) and Rivas and Sutter (2009), provision of the public good in settings with asymmetric power to exclude was significantly higher compared to a baseline setting with no power asymmetries. Furthermore, in Rivas and Sutter (2009), provision of the public good was significantly higher in the setting with asymmetric power to exclude compared to the setting with asymmetric power to reward. O’Gorman et al. (2009) examined power asymmetries in a public-goods setting with sanctioning. In each round, after observing each member’s provision decision, one randomly selected group member could impose sanctions on the other group members. Imposing a sanction lowered the earnings of both the subject imposing the sanction and the receiver. Provision of the public good was significantly higher in this sanctioning setting compared to a baseline setting with no sanctioning and no power asymmetries. The allocator mechanism examined in this paper further examines power asymmetries in provision settings by assigning an allocator power to allocate shares of a CPR between the other group members. 5

The remainder of the paper is organized as follows. Section 2 describes the decision setting. Section 3 offers predictions. Section 4 presents the experimental results. Section 5 contains concluding comments.

4 The decision setting of the linear CPR game studied in this paper resembles that of a linear public good (Isaac and Walker 1988), but with one key difference. In a linear public good game, contributions to provision of the public good create a benefit to each group member. Benefits are non-rival among group members. In the linear CPR game, contributions to provision of the CPR create a fixed resource that is rival, a greater share to one group member implies a smaller share to other group members. See Cox, et al. (2013) for further discussion of this point.

5 Other, less related, experimental studies provide further evidence related to levels of public-good provision and rewarding and sanctioning (Sefton et al. 2007, Baldassarri and Grossman 2011, and Carpenter et al. 2012). Also, there are other experimental studies that provide further evidence related to levels of public-good provision and asymmetric power (Levati et al. 2007, Norton and Isaac 2010, Hamman et al. 2011, Makowsky et al. 2012, and Cox et al. 2013).
2. THE DECISION SETTING

The experimental sessions were conducted at Indiana University-Bloomington. Undergraduate subjects from a wide range of disciplines were recruited from classrooms and from an online subject data base. At the beginning of each decision sequence, subjects privately read a set of instructions, which were then summarized publicly. After reading the instructions, subjects took a post-instruction quiz and were not allowed to continue until all answers were correct. Subjects made all decisions on computers in private.6

Each session consisted of two sequences of 10 rounds, which was public information. Subjects were told that instructions regarding Sequence 2 would be given at the conclusion of Sequence 1.7 Each round in each session had two stages. Provision decisions were made in stage 1. The CPR was allocated in stage 2. Sequence 1 employed the egalitarian mechanism in all sessions, while in Sequence 2 the allocation mechanism varied based on the three mechanisms discussed above. Treatment conditions are identified by the allocation mechanism used in Sequence 2: provision-allocator, provision-tremble, and provision-egalitarian.

At the beginning of a session, the computer randomly and anonymously assigned subjects to four-person groups. No person could identify his/her group members. Each session had 16 or 20 persons. In the provision-tremble and provision-egalitarian treatments, these groups remained intact for both Sequence 1 and 2. Since no information passed across groups, each session involved 4 to 5 independent groups. In the provision-allocator treatment, at the conclusion of Sequence 1, all groups stayed intact except for one. As discussed in more detail below, one group was chosen randomly, with its members becoming the allocators for each of the other groups. When provision-allocator sessions had 20 subjects, there were 4 independent five-person groups in Sequence 2. In the provision-allocator sessions with 16 subjects, there were 3 independent five-person groups in Sequence 2. The remaining subject in a 16-subject session received a $5 exit fee.

In aggregate, data were collected from 152 subjects. Table 1 summarizes the design for each treatment. All subjects were paid a $5 show-up fee. In all sessions, monetary information was denominated in ECUs (Experimental Currency Units). The conversion rate of ECUs to U.S. dollars was 20 to 1. Earnings averaged $23.55 per subject across all sessions, which ranged in duration from 60 to 90 minutes.

2.1. Sequence 1 Decisions

Similar to other studies examining institutional changes within social dilemma experiments, Sequence 1 allowed subjects the opportunity to gain experience in the same baseline decision setting and allowed for statistical control of group effects. In the discussion that follows, decisions to provide the group fund will be referred to as “provision decisions” and decisions to distribute the group fund among group members will be referred to as “allocation decisions.” As noted above, the egalitarian mechanism was used for all decisions in Sequence 1. In each round, each person made a provision decision, how

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6 Co-author Stoddard conducted all experiment sessions, including a review of the instructions. The experiment was programmed by Stoddard using Z-tree (Fischbacher 2007).
7 See the Appendix for a copy of the instructions. The instructions for the allocator mechanism are similar to those of the “King Provision Game” in Cox et al. (2013).
many tokens from an endowment of 10 tokens in his/her individual fund to move a group fund. Each person earned 1 ECU for each token remaining in his/her individual fund. Each token moved to the group fund produced 2.4 ECUs for the group. The egalitarian mechanism divided the group fund evenly between group members; thus, each person received 0.6 ECUs for each token provided to the group fund. At the conclusion of each round, each subject was informed of his/her group’s aggregate provision of the group fund and his/her round earnings. Subjects received this information from previous rounds in a history table.⁸

2.2. Sequence 2 Decisions

2.2.1. The Provision-Allocator Treatment

Sequence 2 of the provision-allocator treatment had five-person groups. All groups from Sequence 1, except one, remained intact. Subjects in the groups that remained intact were referred to as Type-X persons. One group from Sequence 1 was chosen at random. Persons from this group became the fifth member of the groups that remained intact. The fifth member of a group was referred to as the Type-Y person. The Type-Y persons were chosen from one group to control, in the least disruptive way, for any group effects that may have developed in Sequence 1. Each decision round had two stages. In stage 1, the Type-X persons performed the same task as in Sequence 1. In stage 2, the Type-Y person allocated the group fund. The Type-Y person was informed of the provision decision of each Type-X person to the group fund, identified by their anonymous ID letter.⁹ The Type-Y person’s endowment remained in his/her individual fund. After observing the Type-X persons’ decisions, the Type-Y person allocated the group fund in two steps. First, the Type-Y person chose one of three exogenously determined division rules:

- Rule 1: Each Type-X person receives 25% of the group fund.
- Rule 2: Two Type-X persons receive 10% of the group fund and two Type-X persons receive 40% of the group fund.
- Rule 3: Two Type-X persons receive 0% of the group fund and two Type-X persons receive 50% of the group fund.

Second, the Type-Y person allocated each Type-X person a share of the group fund based on the chosen rule. Each round a Type-X person earned the ending value of his/her individual fund plus his/her allocated share of the ending value of the group fund. Each round the Type-Y person earned the value of his/her 10 tokens in his/her individual fund plus an amount equivalent to 25% of the ending value of the group fund.¹⁰ The Type-Y person did not make a provision decision so that, for control purposes across treatments, earnings from the group fund in Sequence 2 would depend on the provision decisions of four group members. Also, for control purposes across treatments, the earnings of the Type-Y person were not taken from the group fund, though his/her earnings were increasing in the value of the group fund. The structure imposed on the division rules available to the Type-Y person was done with forethought of the

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⁸ Unlike the other two treatment conditions, the egalitarian mechanism can be viewed as a common-property resource that is allocated equally or a linear public good with symmetric marginal benefits.

⁹ Type-X persons received ID letters A-D and the Type-Y person received the ID letter Y. ID letters were only used under the allocator mechanism.

¹⁰ The allocator is not an “impartial spectator” because each round he or she receives a payoff directly correlated to the ending value of the group fund. See Croson and Konow (2009) for an example of an experiment investigating allocation decisions made by impartial spectators.
empirical analysis of the Type-X decisions conditional on the Type-Y allocations of the group fund. Compared to a setting that imposes fewer restrictions on the division rules, restricting the division rules to three possibilities results in a larger sample size of Type-X reaction decisions associated with a given Type-Y division rule.

At the conclusion of each round, each subject was informed of his/her group’s aggregate provision decision, and his/her round earnings. Each subject also had access to a history table that reported this information and his/her individual provision decisions for all previous rounds. The Type-X history table also included the division rule chosen by the Type-Y person and the share of the group fund he/she received.\(^\text{11}\) The Type-Y person’s history table reported each Type-X person’s provision decisions and allocated shares of the group fund, using their anonymous ID letters, for all previous rounds.\(^\text{12}\)

2.2.2 The Provision-Tremble Treatment

As a benchmark to more completely analyze the behavioral impact of human allocators, the provision-tremble treatment was conducted. In Sequence 2 of the provision-tremble treatment, one of the three division rules discussed above for the allocator mechanism was randomly assigned to a group each decision round.\(^\text{13}\) Each division rule had an equal probability of being chosen and each group member had an equal probability of being allocated a share of the group fund based on the chosen division rule. The history table provided to subjects in the provision-tremble treatment was identical to that provided to Type-X persons in the provision-allocator treatment, except that division rules were chosen with equal probability.

2.2.3. The Provision-Egalitarian Treatment

In this treatment condition, Sequence 2 decisions used the same allocation mechanism as in Sequence 1, the egalitarian mechanism. The primary purpose of this treatment was to control for learning and history effects that may occur in groups moving across decision rounds from Sequence 1 to Sequence 2. The history table in this treatment reported a subject’s individual provision decisions, his/her group’s aggregate provision decisions, and his/her round earnings for all previous rounds.

3. PREDICTIONS

3.1. Sequence 1 Decisions

In each treatment subjects play a finitely repeated game with a known final round. The theoretical prediction under the one-shot egalitarian mechanism is straightforward, assuming common knowledge that each group member maximizes his/her own material self-interest. Since the individual marginal benefit from a token in an individual fund, 1 ECU, is greater than the individual marginal

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\(^1\) Type-X persons did not observe the individual provision decisions of the other group members or the share of the group fund the other group members received.

\(^2\) Since the Type-Y person was in a different group during Sequence 1, his/her history table only reported information for previous rounds in Sequence 2. See the Appendix for illustrative examples of the history tables.

\(^3\) The tremble mechanism also differed from the allocator mechanism in that provision of the group fund did not generate an external benefit to a fifth person.
benefit from a token in the group fund, 0.6 ECUs, the one-shot Nash equilibrium is for each member to provide zero tokens to the group fund. As noted above, during Sequence 1 of all treatments, however, subjects play with incomplete information. Subjects know there will be a second sequence of 10 rounds, but are not given additional information. Game theoretic predictions under incomplete information, in this case, depend on the persons’ beliefs about Sequence 2. Assuming common knowledge that all group members believe that decisions from Sequence 1 will not affect the game in Sequence 2, the material self-interested subgame Nash equilibrium is to provide zero tokens to the group fund in each round in Sequence 1 for all treatments. On the other hand, research on linear public-goods games indicates that aggregate provision of the group fund is positive and positively correlated with the marginal benefit of the group fund relative to the individual fund (Isaac et al. 1994, and Ledyard 1995). These and other experimental results that differ from “classical” equilibrium predictions have led to models with alternative preference structures (Fehr and Schmidt 1999, Bolton and Ockenfels 2000, Fischbacher et al. 2001, Croson 2007, and Cox et al. 2008). Based on this evidence, aggregate provision of the group fund is predicted to be positive.

3.2. Sequence 2 Decisions

3.2.1 The Provision-Allocator Treatment

In the final round of Sequence 2 of the provision-allocator treatment, it is clear that the Type-Y person’s payoff is independent of the division rule he/she chooses. Thus, because the allocator’s decision lacks strategic motivations, any allocation decision will not be credible to the Type-X persons without assumptions on their beliefs regarding Type-Y behavior. This implies the existence of multiple equilibria dependent on the beliefs of the Type-X persons. Experimental and theoretical evidence suggest the equilibria most likely to be observed are those which consider social preferences, such as equity and reciprocity (Fehr and Schmidt 1999, Bolton and Ockenfels, Croson 2007, and Cox et al. 2008). Additionally, experimental evidence suggests subjects’ actions in the final round are conditioned on their actions from previous rounds. For example, in the reward-sanction literature, subjects continue assigning costly rewards or sanctions to other group members in the final round, despite knowing that this cannot increase their earnings (Sefton et al. 2007). This behavior is suggestive of time-invariant social preferences.

If the Type-Y person is assumed to have preferences to “reward” (“punish”) relatively high (low) providers with a greater (smaller) share of the group fund and conditions his/her action in the final round on his/her actions in previous rounds, in all rounds he/she would allocate the group fund proportionately according to the rank order of provision decisions. In this case, rules 2 (two group members receive a 10% share) and 3 (two group members receive a 0% share) will be used when Type-X persons make heterogeneous provision decisions. Rule 1 (each group member receives an equal share) will be used when Type-X persons make homogeneous provision decisions. Also, if Type-X persons believe the Type-Y person will choose division rules in this manner in all rounds, provision of the group fund in Sequence 2 of the provision-allocator treatment will be higher than in Sequence 2 of the provision-allocator treatment. 14

14 Other possible equilibria include those where the allocator chooses the same division rule in every round. For instance, if an individual knew division rule 3 would be chosen and his/her share of the group fund would be 50% in each round, that individual would have a dominate strategy to provide his/her full endowment of tokens to the group fund. That is, in each round that individual’s marginal benefit from the group fund of 1.2 ECUs would be greater than the marginal benefit from the individual fund of 1 ECU.
egalitarian treatment due to Type-X beliefs of receiving a greater (smaller) share of the group fund for making a relatively high (low) provision decision.\textsuperscript{15}

3.2.2. The Provision-Tremble Treatment

Recall that in Sequence 2 of the provision-tremble treatment, each division rule has an equal probability of being chosen and each group member has an equal probability of being assigned a share of the group fund based on the chosen division rule. For an individual group member this implies $\text{Prob}(\text{share}=0\%) = \text{Prob}(\text{share}=10\%) = \text{Prob}(\text{share}=40\%) = \text{Prob}(\text{share}=50\%) = 1/6$ and $\text{Prob}(\text{share}=25\%) = 2/6$.\textsuperscript{16} Thus, the expected share of the group fund for each group member is 25%. Assuming group members are risk neutral, the marginal incentives are the same as in the egalitarian treatment. Thus, provision of the group fund in Sequence 2 of the provision-tremble treatment will not be different than in Sequence 2 of the provision-egalitarian treatment. Fischbacher et al. (2012), however, found evidence contrary to this theoretical prediction in a one-shot setting with incentives similar to the tremble mechanism. In groups of four, two group members were randomly given approximately 20% of the group fund and two group members were randomly given approximately 30%, but the per-token total production of the group fund remained constant. They found that provision of the group fund was lower in this setting compared to a setting where each group member received 25% of the group fund with certainty.\textsuperscript{17}

3.2.3. The Provision-Egalitarian Treatment

The provision-egalitarian treatment has the same predictions as in Sequence 1.

4. RESULTS

The data are analyzed on three levels: group-level provision of the group fund, individual-level Type-X provision decisions, and individual-level Type-Y allocations to Type-X group members. For brevity in the discussion of results, we will refer to the allocator treatment as PA, the egalitarian treatment as PE, and the tremble treatment as PT.\textsuperscript{18}

\textsuperscript{15} The scenario described above is not an equilibrium because the 2x2 nature of the shares in division rules 2 and 3 give additional incentives to free-ride. If the allocator was able to allocate strictly based on the rank order of provision decisions, the scenario described above would be a subgame Nash equilibrium where each Type-X person provides his/her entire endowment of resources to the group fund and receives an equal share of the group fund from the Type-Y person.

\textsuperscript{16} With the tremble mechanism, agents know the probabilities of receiving a particular share of the Group Fund. Thus, the tremble mechanism implies risk (Knight 1921).

\textsuperscript{17} Other, somewhat related, linear public-goods studies examine risky and uncertain marginal benefits (Dickinson 1998, Gangadharan and Nemes 2009, Levati et al. 2009, Levati and Morone 2012, and Stoddard 2013a and 2013b). These linear public-goods studies are different because the marginal benefits are always homogeneous across group members and the total production of the group fund varies with the realization of the marginal benefits.

\textsuperscript{18} For the remainder of the paper, Type-X persons will refer to subjects from all three treatments that make a provision decision. In the experimental sessions, however, these subjects were only referred to as Type-X persons in Sequence 2 of the PA treatment.
4.1 Group-Level Analysis

The discussion of group-level decisions begins with a graphical presentation accompanied by summary statistics and statistical tests. The descriptive analysis is followed by a more formal regression analysis.

4.1.1. Descriptive Overview

Figure 1 displays the path of mean group provision of the group fund for each treatment condition. Table 2 presents the means and standard deviations of group provision of the group fund across sequences and treatments.

Recall, the egalitarian allocation mechanism is used in all treatments in Sequence 1. The pattern of mean provision of the group fund across decision rounds in Sequence 1 is similar across all three treatments, except that mean group fund provision in the PA treatment is (weakly) higher than in the PE treatment (PA vs PE Wilcoxon rank-sum p=0.095, n=26; PA vs PT p=0.495, n=22; PE vs PT p=0.487, n=20). Pooling across Sequence 1 of all treatments yields a pattern of mean group fund provision consistent with other linear provision games with similar marginal incentives (see Sefton et al. 2007). Round 1 group-fund provision was 58% of the aggregate endowment and round 10 group-fund provision was 45%, well above the self-interested Nash prediction of zero provision of the group fund.

Figure 1 indicates that in all treatments there is a restart effect, common to voluntary provision games with multiple sequences; group-fund provision is higher in round 11 than 10 (PE paired t-tests p=0.008, n=12; PT p=0.086, n=8; PA p=0.022, n=14). Further, group-fund provision in round 11 is not significantly different across treatments (PA vs PE Wilcoxon rank-sum p=0.303, n=26; PA vs PT p=0.657, n=22; PE vs PT p=0.487, n=20). Mean group-fund provision in Sequence 2 of the PE and PT treatments decays over time, beginning near 60% of the aggregate endowment and ending near 40%. However, in the PA treatment, group-fund provision starts at approximately the same level as the other treatments, but thereafter is maintained over decisions rounds, ending above 75%. Pairwise comparisons to the PA treatment show that mean group-fund provision is significantly different in round 20 and across all rounds in Sequence 2. Consistent with the theoretical prediction discussed above,

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19 Each group is treated as an independent observation. To test the overall homogeneity of group-level provision of the group fund across treatments, the group-fund provisions are averaged across all decision rounds for each group. All nonparametric tests use the two-sample Wilcoxon (Mann-Whitney) rank-sum statistic where the null hypothesis is that the samples are drawn from the same population distribution. Two-tailed paired t-tests are used to test for differences in group-fund provision over time within the same treatment where the null hypothesis is that average group-fund provision is the same in each time interval.

20 To compare group-fund provision for each group across sequences, the group data from the four Sequence 1 groups whose members were later assigned as Type-Y persons were dropped. The results are robust to including the data from those groups.

21 Differences in rounds 1 and 10 (PE paired t-test p=0.118, n=12; PT p=0.073, n=8; PA p=0.622, n=14).

22 Differences in rounds 11 and 20 (PE paired t-test p=0.000, n=12; PT p=0.085, n=8; PA p=0.125, n=14).

23 Differences in group-fund provision in round 20 (PA vs PE Wilcoxon rank-sum p=0.000, n=26; PA vs PT p=0.001, n=22); comparing average Sequence 2 group-fund provision (PA vs PE Wilcoxon rank-sum p=0.001, n=26; PA vs PT p=0.002, n=22).
mean group-fund provision in the PE and PT treatments in round 20 and across all rounds in Sequence 2 are not significantly different.\textsuperscript{24}

The significant difference in mean group-fund provision in the PA treatment in Sequence 2 compared to each of the other two treatments might be expected due to the group effect in the PA treatment in Sequence 1. Comparisons of mean changes between Sequence 1 and Sequence 2, however, indicate a significant difference across sequences only in the PA treatment.\textsuperscript{25}

Clearly, the pooled averages plotted in Figure 1 mask the degree of variation across groups in each treatment. Figure 2 shows the group-fund provision for all 20 rounds for each group. Marked variation exists across groups and across treatment conditions. The primary observation that comes from this display, however, is that the decay in group-fund provision observed for many groups in Sequence 2 of the PE and PT treatments is not observed for groups in the PA treatment. Figure 3 displays the mean within-group standard deviation of individual provision decisions. The pattern of within-group standard deviation of individual provision decisions across rounds indicates a treatment effect. The mean within-group standard deviation is significantly lower in Sequence 2 of the PA treatment than in Sequence 2 of the other two treatments (PA vs PE Wilcoxon rank-sum p=0.03, n=26; PA vs PT p=0.01, n=22; PE vs PT p=0.82, n=20).\textsuperscript{26}

\textbf{4.1.2. Regression Analysis: Sequence 1 Decisions}

Table 3 presents results from an OLS regression analysis pooling observations from all Sequence 1 decisions. The dependent variable is group-level provision of the group fund. The independent variables are dummies for treatments and rounds, with the PE treatment serving as the reference treatment condition. The unit of observation for time-variant variables in all regressions is a decision round, yielding 10 observations per group. Recall, the egalitarian mechanism was used for all decisions in Sequence 1. Thus, any differences across treatment conditions are due to group effects.

The results from the OLS analysis confirm the observations from the descriptive overview. Compared to the PE treatment, group-fund provision in Sequence 1 is not significantly different in the PT treatment. Compared to the PE treatment, group-fund provision in Sequence 1 is not significantly different at the 5\% level (two-tailed test) in the PA treatment. Further, the pair-wise null hypothesis for the significance of the coefficients for the PA and PT treatments is not rejected using a Wald Test: PA = PT (p=0.233).\textsuperscript{27}

\textsuperscript{24} Differences in group-fund provision in round 20 (PE vs. PT Wilcoxon rank-sum p=0.440, n=20); comparing average Sequence 2 group-fund provision (PE vs. PT Wilcoxon rank-sum p=0.700, n=20).

\textsuperscript{25} Differences in mean group-fund provision across all rounds in Sequence 1 to mean group-fund provision across all rounds in Sequence 2 (paired t-test, PA p=0.000, n=14; PE p=0.688, n=12; PT p=0.336, n=8).

\textsuperscript{26} Paired t-tests comparing differences in mean within-group standard deviation across all rounds in Sequence 1 to mean within-group standard deviation across all rounds in Sequence 2 support these conclusions.

\textsuperscript{27} The following alternative models were examined as robustness checks for the model reported in Table 3: random-effects panel model, two-limit censored-normal (Tobit) regression model (Cameron and Trivedi 2005, chapter 16.3), and similar models without round-dummy variables. Results in Table 3 are robust across these models.
### 4.1.3. Regression Analysis: Sequence 2 Decisions

Table 4 reports an estimated pooled OLS model for observations from Sequence 2. To control for any group effects from Sequence 1, the dependent variable is the difference between group-level provision in Sequence 2 and the mean group-level provision for each group in Sequence 1. The estimated model uses treatment and round dummies as independent variables, with the PE treatment serving as the reference condition.

As described in the descriptive overview, compared to the PE treatment, the difference in group-fund provision between sequences is significantly higher in the PA treatment and not significantly different in the PT treatment. This conclusion is supported further by a Wald test of regression coefficients that rejects the null hypothesis that PA = PT (p=0.000). Thus, even after accounting for the somewhat higher group-fund provision levels in some groups in Sequence 1 of the PA treatment, the increase in group-fund provision during Sequence 2 of this treatment suggests a strong facilitative effect of the allocator mechanism in comparison to the other mechanisms.\(^{28}\)

### 4.2. Type-X Individual-Level Analysis

#### 4.2.1. Regression Analysis: Sequence 1 Decisions

Table 5 reports three random-effects panel models, one for Sequence 1 of each treatment. The dependent variable in each regression is the change in an individual’s provision decision in round \(t\) minus the provision decision in round \((t-1)\). The random-effects models control for the (Type-X) subject-specific effect in addition to the idiosyncratic error. The independent variables are the one-round lagged deviation of person \(i\) from the mean provision decision of his/her other three group members and round dummies.

Consistent with previous linear public-good studies, the negative sign of the coefficients for lagged deviation from other group members suggests the presence of reciprocal norms in the decision strategies used by Type-X subjects. In spite of the fact that all groups in Sequence 1 used the PE mechanism (without knowledge of what to expect in Sequence 2), Wald tests of regression homogeneity reveal that the Sequence 1 data for the PA subsample are significantly different than the PE and PT subsamples. The statistical significance of this difference would presumably vanish with a sufficiently large sample. The joint null hypothesis of homogeneous coefficients across pairwise Sequence 1 subsamples is rejected (p<0.05) for PE=PA and PT=PA, but not for PE=PT (p>0.10).\(^{29}\)

#### 4.2.2. Regression Analysis: Sequence 2 Decisions

Table 6 reports three random-effects panel models, one for Sequence 2 of each treatment. As in Table 5, the dependent variable in each regression is the change in an individual’s provision decision in round \(t\) minus the provision decision in round \((t-1)\). The primary purpose of the models is to examine the effect on the change in provision decisions of the share of the group fund received in the prior round. These models control for a subject-specific effect, in addition to the idiosyncratic error. The independent

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\(^{28}\) The following alternative models were examined as robustness checks for the model reported in Table 4: a random-effects panel model, a pooled OLS model with group-level provision as the dependent variable, and similar models without round-dummy variables. Results in Table 4 are robust across these models.
variables are round dummies, one-round lagged share of the group fund, and one-round lagged deviation of person $i$ from the mean provision decision of his/her other three group members.

As in the Sequence 1 Type-X analysis shown in Table 5, the coefficient for lagged deviation from the other group members is negative and significant in all treatments. This suggests the presence of reciprocal norms in Sequence 2. The analysis also suggests the decision strategies used by Type-X subjects are dependent on the allocation mechanism. The coefficient of lagged share in the PT treatment is not significant. However, with the allocator mechanism, it appears provision decisions are strongly associated with the lagged share of the group fund allocated by the Type-Y person. A Wald test of the homogeneity of regression coefficients across the PT and PA models indicates a marginally significant treatment effect (reject PT=PA, p<0.10).

To further investigate the impact of the allocator mechanism on provision decisions, Figure 4 displays the mean token responses of Type-X subjects to the one-round lagged share of the group fund received from the Type-Y person by comparing the difference in provision decisions between rounds (t) and (t-1) to their share of the group fund in round (t-1). Type-X responses are separated into two categories based on tokens they provided to the group fund in round (t-1): [0, 8] and [9, 10]. As one can see from the two panels in Figure 4, the largest response to allocation shares occurred for Type-X subjects who made group-fund provisions below the group median and received a 0% or 10% share.

4.3 Type-Y Individual Level Analysis

4.3.1 Descriptive Overview

Tables 7-8 and Figure 5 report an analysis of the allocation decisions made by 14 Type-Y subjects in Sequence 2 of the PA treatment. Table 7 reports the frequency of use for each division rule in the PA treatment and, for control purposes, the PT treatment. In the PT treatment, since each rule had an equal probability of being chosen, the rules were used with approximately the same frequency. In the PA treatment, rule 1 (each group member receives an equal share) was used disproportionately more than the two other rules. The Type-Y subjects’ preference for the egalitarian rule could be linked to the history of decisions in Sequence 1, where all groups faced the egalitarian mechanism. Another possible explanation for this result is that, relative to the other treatment conditions, provision decisions were quite high and relatively symmetric in the PA treatment in many decision rounds, as shown by the lower within group standard-deviations in Figure 3. There is strong evidence that allocators also used rules 2 and 3 to reward those subjects who made higher provision decisions. Figure 5 displays the relationship between the mean share of the group fund a Type-X person receives and the provision decision of a Type-X person as a

29Unlike the traditional Chow test of regression homogeneity, the Wald test used here is conducted by pooling data across subsamples and then including subsample dummy and interaction terms. The null hypothesis is that the dummy and interaction coefficients are jointly zero. The Wald test utilizes the estimated variance-covariance matrix from the regression, which incorporates the robust variance estimates with clustering.

30Figure 4 pools data from all rounds and all groups in Sequence 2 of the PA treatment. The two categories shown in Figure 4 were chosen on the basis of the median provision decision of 9 tokens. However, the results are robust to different bin distributions.

31Figure 4 also reports 12 instances where Type-X subjects made high group-fund provisions and received a zero share of the group fund. In most cases, this occurred in groups where one subject made lower group-fund provision than the others. Choosing rule 3 allowed an allocator to give the lowest provider a zero share, but also meant one of the high providers would also get a zero share.
percentage of the total group-level provision. Percentages of total group-level provision are organized in bins ranging from 0%-50%, each bin containing 10 percent increments. The largest bin, (40%, 50%), contains the maximum observed individual provision decision as a percentage of total group-level provision, 48%. As seen, Figure 5 indicates a strong positive correlation between the share of the group fund a Type-X person receives and that person’s provision decision as a percentage of his/her group’s total provision of the group fund.32

4.3.2 Regression Analysis

The results from Figure 5 are supported by regression analysis. Table 8 reports a random-effects panel regression model examining Type-Y allocation decisions. The random-effects model controls for the (Type-X) subject-specific effect in addition to the idiosyncratic error. The dependent variable is the share of the group fund allocated to each Type-X person. The independent variables are round dummies, the percentage of total group-level provision, and the change in percentage of total group-level provision in round (t) minus the percentage of total group-level provision in round (t-1).

In support of Figure 5, the regression analysis yields a positive relationship between a Type-X person’s provision decision and share of the group fund received, with a coefficient of 0.78. In addition, the coefficient for the percentage change variable is significant and positive. That is, controlling for an individual’s group-level provision in the current round, a Type-Y person on average allocated a larger (smaller) share of the group fund to a Type-X person if his/her individual percentage of total group-level provision increased (decreased) from the previous round. Thus, on average, Type-Y subjects also “rewarded” Type-X subjects that increased their provision level compared to the previous round, while they “punished” Type-X subjects that decreased their provision level.33

5. CONCLUSION

This paper focuses on the impact of an allocator on the voluntary provision of a common-property resource. The allocator mechanism examined assigns a randomly-chosen group member the power to allocate the CPR among the other group members according to exogenously-determined division rules, after observing their provision decisions. In order to determine the impact of the allocator mechanism on group-fund provision, three treatments with two sequences of 10 decision rounds were conducted. Sequence 1 in each treatment employed the egalitarian mechanism. Sequence 2 varied the allocation mechanism employed: allocator, tremble, and egalitarian. The results support the conclusion that group-fund provision in Sequence 2 of the provision-allocator treatment was significantly higher than group-fund provision under two baseline treatments, provision-egalitarian and provision-tremble.

32 Recall, the division rules prevent shares of the group fund from being allocated strictly based on the rank order of provision decisions. This constraint could lead to additional free-riding when three group members have high provision decisions and one has a low provision decision. A 3H-1L group is defined as a group with a Type-X person who provides 5 tokens or less when the other group members’ average provision decision is more than 9 tokens. Pooling data across all rounds in Sequence 2 of a treatment, a 3H-1L type of group occurred 21% of the time in the PA treatment compared to 8% of the time in the PE treatment and 6% of the time in the PT treatment. Pairwise equality-of-proportion tests suggest 3H-1L free riding occurred significantly more often in the PA treatment (PA vs. PE p=0.0017; PA vs. PT p=0.0031; PE vs. PT p=0.7343).
33 The following alternative models were examined as robustness check for the models reported in Table 8: random-effects panel model that clustered errors by Type-X subjects, pooled OLS models with errors clustered by either groups or Type-X subjects, two-limit censored-normal (Tobit) regression model, and similar models without round-dummy variables. Results in Table 8 are robust across these models.
Further, within-group standard deviation of provision decisions was significantly lower in the provision-allocator treatment than in the other two treatments.

Analysis of the individual-level Type-X data suggested that decision strategies were dependent on the allocation mechanism employed. In Sequence 1, individual provision decisions from the provision-egalitarian mechanism were significantly and negatively affected by the deviation of the lagged provision decision from the mean of others’ provision decisions, suggesting the presence of reciprocal norms. This is also true for all three allocation mechanisms in Sequence 2. Using the provision-allocator mechanism, Sequence 2 individual provision decisions were also significantly and negatively affected by the lagged share of the group fund assigned by the Type-Y person. On average, Type-X subjects in the provision-allocator treatment who provided less than the median provision decision and received less than 25% of the group fund in the prior round responded by increasing their provision decisions in the next round. This is not the case using the provision-tremble mechanism.

Analysis of the individual-level Type-Y subjects showed a strong positive correlation between the share of the group fund a Type-Y person allocated to a Type-X person and the Type-X person’s provision decision as a percentage of the group’s total provision of the group fund. Combining the evidence supporting reward-sanction allocations by the Type-Y subjects, greater group-fund provision, and lower within-group variation of provision decisions under the allocator mechanism, it follows that rule 1 (each group member receives an equal share) was the rule most used by Type-Y subjects.

This study sheds light on a long history of implementing allocator-type mechanisms in naturally-occurring settings. The results are important for understanding the economic incentives and behavior associated with such mechanisms, and could lead to more efficient policy adaptations for the provision of common-property resources. In addition, the results from this study can be viewed as applying to non-profit organizations that provide public goods through multiple branches and programs (such as charitable and environmental organizations, as well as public radio/TV). Donations to these organizations create a common pool of resources that are allocated for, among other things, the production of public goods. Unlike the allocator mechanism examined in this paper, such organizations are not limited to allocating resources to one division rule. In practice, donated resources could be allocated using alternative division rules for the provision of a variety of public goods.

Finally, it is often the case that public goods produced by an organization provide differentiated marginal benefits across donors. For instance, if an organization uses resources to maintain hiking trails throughout the country, a donor is likely to receive greater benefits from resources used to maintain trails that are in close proximity to his/her home. This study provides a behavioral foundation for examining the efficacy of the allocator mechanism in such settings.
REFERENCES


The Church of Jesus Christ of Latter-day Saints, 1981. Doctrine and Covenants. The Church of Jesus Christ of Latter-day Saints, Section 51, 94-95.


**TABLES AND FIGURES**

Table 1- Design Information for Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sequence 1 Allocation Mechanism</th>
<th>Sequence 2 Allocation Mechanism</th>
<th>Independent Groups (Sequence 1)</th>
<th>Independent Groups (Sequence 2)</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision-Egalitarian</td>
<td>Egalitarian</td>
<td>Egalitarian</td>
<td>12</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>Provision-Tremble</td>
<td>Egalitarian</td>
<td>Tremble</td>
<td>8</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Provision-Allocator</td>
<td>Egalitarian</td>
<td>Allocator</td>
<td>18</td>
<td>14</td>
<td>72/70</td>
</tr>
</tbody>
</table>

Recall, all treatments began with the egalitarian mechanism in Sequence 1.

Table 2- Summary Statistics: Group-Level Data, by Sequence and Treatment

<table>
<thead>
<tr>
<th>Mean Group Provision of the Group Fund (standard deviation)</th>
<th>Sequence 1</th>
<th>Sequence 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision-Egalitarian</td>
<td>19.36</td>
<td>18.75</td>
</tr>
<tr>
<td></td>
<td>(7.72), N=12</td>
<td>(7.51), N=12</td>
</tr>
<tr>
<td>Provision-Tremble</td>
<td>21.9</td>
<td>20.03</td>
</tr>
<tr>
<td></td>
<td>(6.44), N=8</td>
<td>(5.60), N=14</td>
</tr>
<tr>
<td>Provision-Allocator</td>
<td>24.42</td>
<td>31.08</td>
</tr>
<tr>
<td></td>
<td>(7.17), N=14</td>
<td>(5.65), N=14</td>
</tr>
</tbody>
</table>
Table 3- Group-Level Provision, Pooled OLS Regression: Pooled Across All Sequence 1 Decisions

<table>
<thead>
<tr>
<th>Dependent Variable: Group-Level Provision</th>
<th>Provision-Tremble</th>
<th>Provision-Allocator</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.54 (3.11), [p=0.420]</td>
<td>5.06 (2.91), [p=0.091]</td>
<td>20.02 (1.84), [p=0.000]</td>
</tr>
</tbody>
</table>

The reference categories are the Egalitarian treatment and round 1. Round dummies for rounds 2 and 3 are positive and significant at the 5% level. Round dummies for rounds 7 and 10 are negative and significant at the 5% level. Figures in parentheses are robust standard errors clustered on 34 independent groups, 10 observations per cluster.

R²=0.12; N=340

Table 4- Group-Level Provision, Pooled OLS Regression: Pooled Across All Sequence 2 Decisions

<table>
<thead>
<tr>
<th>Dependent Variable: Difference between Group-Level Provision in Sequence 2 and Mean Group-Level Provision from Sequence 1 for each Group</th>
<th>Provision-Tremble</th>
<th>Provision-Allocator</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.27 (2.28), [p=0.582]</td>
<td>7.27 (1.91), [p=0.001]</td>
<td>1.32 (1.57), [p=0.406]</td>
</tr>
</tbody>
</table>

The reference categories are the Egalitarian treatment and round 11. Round dummy for round 20 is negative and significant at the 5% level. Figures in parentheses are robust standard errors clustered on 34 independent groups, 10 observations per cluster.

R²=0.27; N=340
<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Provision-Egalitarian</th>
<th>Provision-Tremble</th>
<th>Provision-Allocator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Deviation from Mean Provision Decision of Other Members</td>
<td>-0.35 (0.04), [p=0.000]</td>
<td>-0.36 (0.03), [p=0.000]</td>
<td>-0.50 (0.06), [p=0.000]</td>
</tr>
<tr>
<td>Constant</td>
<td>0.38 (0.31), [p=0.236]</td>
<td>-0.16 (0.46), [p=0.733]</td>
<td>1.09 (0.32), [p=0.001]</td>
</tr>
</tbody>
</table>

Data from round 1 were dropped because there are no lagged comparisons. The reference category is round 2.

PE:
Dummy variables for rounds 4 and 10 are negative and significant at least at the 10% level. Figures in parentheses are robust standard errors clustered on 12 independent groups, 36 observations per cluster. $R^2=0.22$; N=432

PT:
Dummy variable for round 5 is negative and significant at the 5% level. Figures in parentheses are robust standard errors clustered on 8 independent groups, 36 observations per cluster. $R^2=0.22$; N=288

PA:
Dummy variables for rounds 3-7 and 10 are negative and significant at least at the 5% level. Figures in parentheses are robust standard errors clustered on 14 independent groups, 36 observations per cluster. $R^2=0.28$; N=504
Table 6- 1-Round Change in Type-X Provision Decisions, Random-Effects Panel Regression: Sequence 2 Decisions, by Treatment

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Provision-Egalitarian</th>
<th>Provision-Tremble</th>
<th>Provision-Allocator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Share</td>
<td>---</td>
<td>0.51 (1.32), [p=0.698]</td>
<td>-1.11 (0.58), [p=0.054]</td>
</tr>
<tr>
<td>Lagged Deviation from Mean Provision Decision of Other Members</td>
<td>-0.33 (0.06), [p=0.000]</td>
<td>-0.24 (0.05), [p=0.000]</td>
<td>-0.22 (0.05), [p=0.000]</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.56 (0.33), [p=0.093]</td>
<td>-0.78 (0.58), [p=0.178]</td>
<td>0.56 (0.32), [p=0.080]</td>
</tr>
</tbody>
</table>

Data from round 11 were dropped because there are no lagged comparisons. The reference category is round 12.

PE: Dummy variable for round 16 is positive and significant at the 10% level. Figures in parentheses are robust standard errors clustered on 12 independent groups, 36 observations per cluster. $R^2=0.20$; N=432

PT: Dummy variables for rounds 15 and 20 are positive and significant at the 10% level. Figures in parentheses are robust standard errors clustered on 8 independent groups, 36 observations per cluster. $R^2=0.14$; N=288

PA: Round dummy variables are not significant. Figures in parentheses are robust standard errors clustered on 14 independent groups, 36 observations per cluster. $R^2=0.12$; N=504

Table 7- Frequency of Division Rules

<table>
<thead>
<tr>
<th>Observations from Sequence 2 (Rounds 11-20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Division Rule</td>
</tr>
<tr>
<td>Rule 1 (4x 0.25)</td>
</tr>
<tr>
<td>Rule 2 (2 x 0.10, 2 x 0.40)</td>
</tr>
<tr>
<td>Rule 3 (2 x 0.00, 2 x 0.50)</td>
</tr>
</tbody>
</table>
Table 8- Type-Y Allocation, Random-Effects Panel Regression: Sequence 2 Allocation Decisions

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Provision-Allocator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Total Group-Level Provision</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>(0.10), [p=0.000]</td>
</tr>
<tr>
<td>Change in Percentage of Total Group-Level Provision</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(0.07), [p=0.036]</td>
</tr>
<tr>
<td>Constant</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>(0.03), [p=0.033]</td>
</tr>
</tbody>
</table>

Data from round 11 were dropped because of the lagged variables. The reference category is round 12. Round dummies are not significant and are not reported. Figures in parentheses are robust standard errors clustered on (14) independent groups, 36 observations per cluster. \( R^2 = 0.27; N=504 \)
Figure 1- Mean Group-Fund Provision, by Treatment
Figure 2- Group-Fund Provision, by Group

Provision-Egalitarian

Provision-Tremble
Figure 3- Mean Within-Group Standard Deviation of Individual Provision Decisions, by Treatment
Figure 4 - Provision-Allocator Treatment: Mean Change in Provision Decisions per Lagged Share of the Group Fund
Figure 5- Mean Share of the Group Fund Received in Relation to a Type-X Person’s Provision Decision as a Percentage of Total Group-Level Provision