Provision versus Appropriation in Symmetric and Asymmetric Social Dilemmas

James C. Cox, Elinor Ostrom, Vjollca Sadiraj, and James M. Walker

EXperimental Economics CENter
Andrew Young School at Georgia State University

Much-studied Social Dilemmas for Symmetric Agents

In a standard provision (or public good) game:

- Agents simultaneously choose contributions
- They share equally in the produced public good
- The central question is the significance of under-provision

In a standard appropriation (or common-pool resource) game

- Symmetric agents simultaneously choose extractions
- They share equally in the remaining common pool
- The central question is the significance of over-exploitation

Power Asymmetries

Natural environments with public-good and common-pool social dilemmas are often characterized by power asymmetries.

Our central question is how power asymmetries affect the significance of under-provision and over-exploitation.

Participants in the Experiments

- Undergraduate students at
  - Georgia State
  - Indiana University

Experiment Design

A. Construct pairs of provision and appropriation games with symmetric and asymmetric power:

- All game pairs are strategically equivalent for *homo economicus* theory and all non-reciprocal social preference theories (Fehr-Schmidt, 1999; Bolton-Ockenfels, 2000; Charness-Rabin, 2002; Cox-Sadiraj, 2007, 2010)
- Asymmetric power games are **not** isomorphic for revealed altruism theory (Cox, Friedman, and Gjerstad, 2007; Cox, Friedman, and Sadiraj, 2008)

B. Conduct experiments with the games: one shot (single round)

Specific Questions for Effects of Power Asymmetry

I. Do FMs in provision or appropriation games behave differently when there (a) **are** or (b) **are not** SMs with unequal power?

II. How do SMs with unequal power (“bosses and kings”) actually behave?

III. In light of I and II, what differences are there in the overall level of cooperation achieved, in final outcomes, and in their distribution?

IV. Are the data consistent with:

A. Non-reciprocal (social and economic man) preference theories?
B. Revealed altruism theory?

Baseline Game: 4 Simultaneous Movers

Endowments

PG: Each individual begins with 10 tokens worth $1 each in a Private Fund (PF)

AG: Each group begins with an endowment of 40 tokens worth $3 each in a Group Fund (GF)

Feasible Actions

PG: Each token $x \in \{0,1,\cdots,10\}$ moved from PF to GF by person *j* reduces value of PF by $1 and increases value of GF by $3

AG: Each token $y \in \{0,1,\cdots,10\}$ moved from GF to PF by person *j* reduces value of GF by $3 and increases PF by $1

Baseline Game: 4 Simultaneous Movers (cont.)

Payoffs

PG: Individual's payoff = individual's PF + GF/4

AG: Individual's payoff = individual's PF + GF/4

Group Maximum Payoff

PG: 40 tokens PUT IN the GF with value of $120

AG: 40 tokens LEFT IN the GF with value of $120

Boss Game: 3 First Movers, 1 Second Mover

First Movers' Feasible Actions

First Movers ("workers") have same feasible actions as in baseline game; each can contribute (BPG) or remove (BAG) up to 10 tokens

Boss's Feasible Actions

BPG: Boss moves after seeing decisions of 3 First Movers; she can contribute up to 10 tokens

BAG: Boss moves after seeing decisions of 3 First Movers; she can remove up to 10 tokens

King Game: 3 First Movers, 1 Second Mover

First Movers' Feasible Actions

First Movers ("peasants") have same feasible actions as in baseline game; each can contribute (KPG) or remove (KAG) up to 10 tokens

King's Feasible Actions

KPG: King moves after seeing decisions of 3 First Movers; he can contribute himself or remove FM contributions to GF

KAG: King moves after seeing decisions of 3 First Movers; he can forgo extraction himself or remove any remaining amount in GF

Payoff Equivalence

Simultaneous-Move Provision Game

Each of N agents is endowed with e tokens in a Private Fund and can transfer $x_j \in \{1, 2, \cdots, e\}$ to the Group Fund.

Each token transferred reduces the value of PF by $1 and increases the value of GF by $$M$, where $M < N$.

The money payoff to representative agent i is

$$\pi_i^p = e - x_i + M \sum_{j=1}^{N} x_j / N$$

Payoff Equivalence (cont.)

Simultaneous-Move Appropriation Game

The group of N agents is endowed with a Group Fund containing $E = Ne$ tokens worth \$$M$ each. Each agent can transfer $z_j \in \{1, 2, \cdots, e\}$ to her Private Fund.

Each token transferred reduces the value of GF by \$$M$ and increases the value of PF by \$$M$, where $M < N$.

The money payoff to representative agent i is

$$\pi_i^a = z_i + M(E - \sum_{j=1}^{N} z_j) / N$$

Payoff Equivalence (cont.)

If $e - x_j = z_j$, for $j = 1,2, \ldots, N$ then

$$\pi_i^a = e - x_i + M(Ne - \sum_{i=1}^{N}(e - x_i)) / N$$

$$= e - x_i + M(Ne - Ne + \sum_{i=1}^{N} x_i / N$$

$$= e - x_i + M \sum_{j=1}^{N} x_j / N = \pi_i^p$$

for $i = 1,2, \ldots, N$

Hypotheses

Proposition 1. Assume *homo economicus* preferences. Agents have a dominant strategy to contribute zero to the Group Fund in a provision game or extract the maximum amount possible from the Group Fund in an appropriation game.

Hypothesis 1: Average earnings of players in a provision or appropriation game will be the minimum possible amount $*e*.

Hypotheses (cont.)

Proposition 2. Assume either social preferences or *homo economicus* preferences. In the simultaneous-move games, a vector of appropriations g^* into Individual Funds in the appropriation game

a. is a Nash equilibrium if and only if the vector of amounts g^* retained in Individual Funds is a Nash equilibrium in the provision game

b. allocates to player i the same payoff in the appropriation game as does the vector of amounts g^* retained in Individual Funds in the provision game.

Hypothesis 2: Average earnings of players are the same in the simultaneous provision and appropriation games.

Hypotheses (cont.)

Proposition 3. For fixed (*homo economicus* and social) preferences, in the sequential-move games a vector of appropriations g^* into Individual Funds in the appropriation game

a. is an outcome of a Nash equilibrium if and only if the vector of amounts retained g^* in Individual Funds is an outcome of a Nash equilibrium in the provision game

b. allocates to player i the same payoff as the vector of amounts retained g^* in Individual Funds in the provision game.

Hypothesis 3: Average earnings of players are the same in the sequential provision and appropriation games.

Hypotheses (cont.)

Proposition 4. For sequential-move finite (provision or appropriation) games, for any vector of first movers' choices $\boldsymbol{x}$, the total group payoff from $\boldsymbol{(x, br^{B}(x))}$ in the boss game is (weakly) higher than the total group payoff from $\boldsymbol{(x, br^{K}(x))}$ in the king game.

Hypothesis 4: For any given contributions of the first movers, the total group earnings in a sequential king game are not larger than total group earnings in a sequential boss game.

Hypotheses (cont.)

Proposition 5. Let first movers retain g_{-N} in their Individual Funds in the provision game and add g_{-N} to their Individual Funds in the appropriation game. A second mover with reciprocal preferences characterized by Axioms R and S will add more to his Individual Fund in the appropriation game than he retains in his Individual Fund in the provision game.

Hypothesis 5: Bosses' (resp. kings') contributions to the Group Fund in the provision game are larger than the amounts they leave in the Group Fund in the appropriation game.

Table 1. Nob. of Ind. Subject (and Group) Observations by Treatment

	Simultaneous Games	Boss Games	King Games
Provision Games	32 (8 Groups)	28 (7 Groups)	76 (19 Groups)
Appropriation Games	36 (9 Groups)	32 (8 Groups)	76 (19 Groups)

Table 2. Experimental Earnings by Subject Type and Treatment

	Simul-taneous Games	Boss Games		King Games	
		First Mover	Sec. Mover	First Mover	Sec. Mover
Provision Games	$24.19	$19.53	$21.43	$16.43	$21.92
Approp. Games	$22.39	$20.84	$21.31	$11.04	$22.10

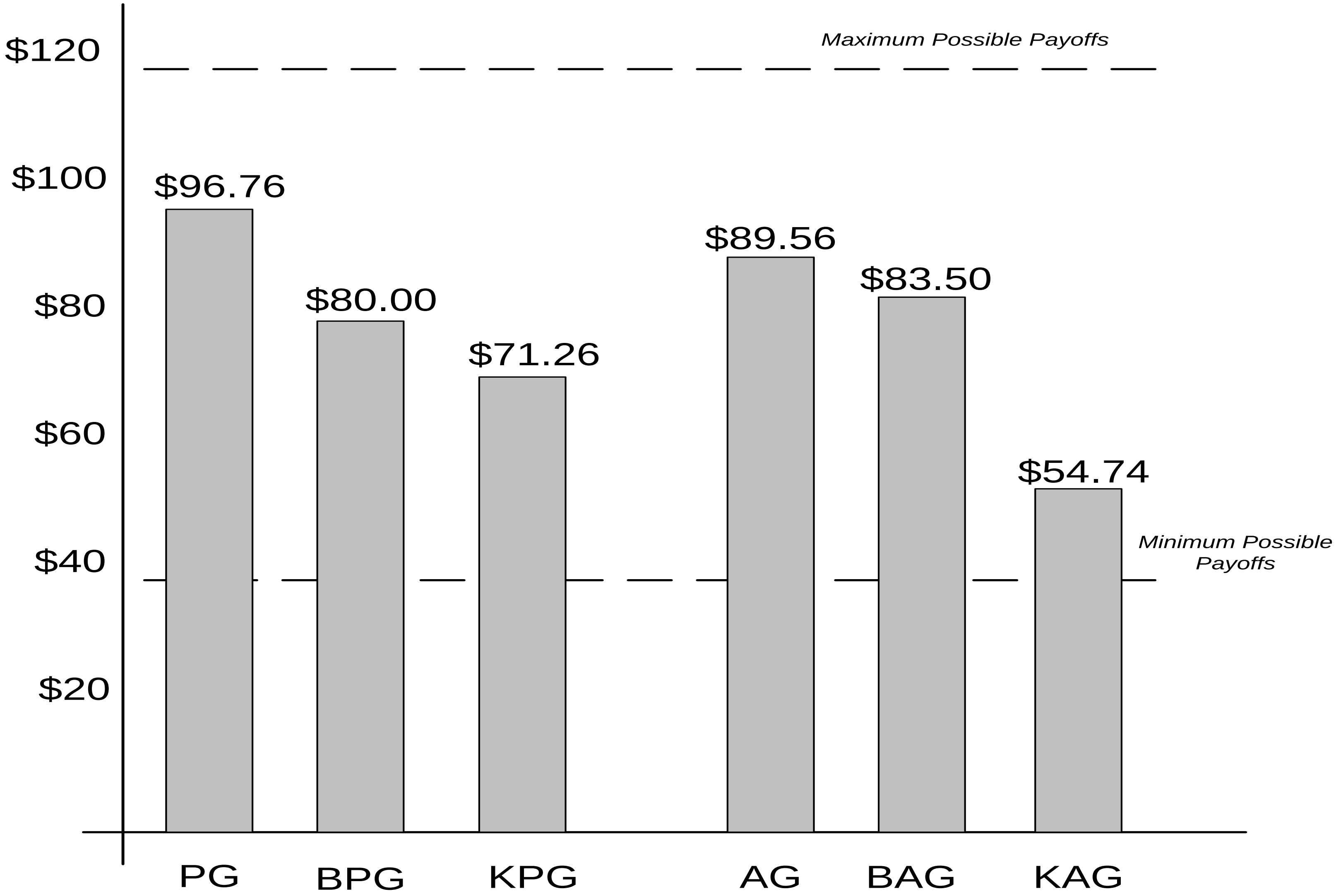


Figure 1. Average Group Earnings by Treatment

Results

Result 1: Average group earnings across the two baseline conditions (PG and AG) are very similar. Earnings are well above the minimum predicted by the dominant strategy equilibrium for the special case of *homo economicus* preferences (which is $40).

Result 1 is inconsistent with Hypothesis 1 but consistent with Hypothesis 2.

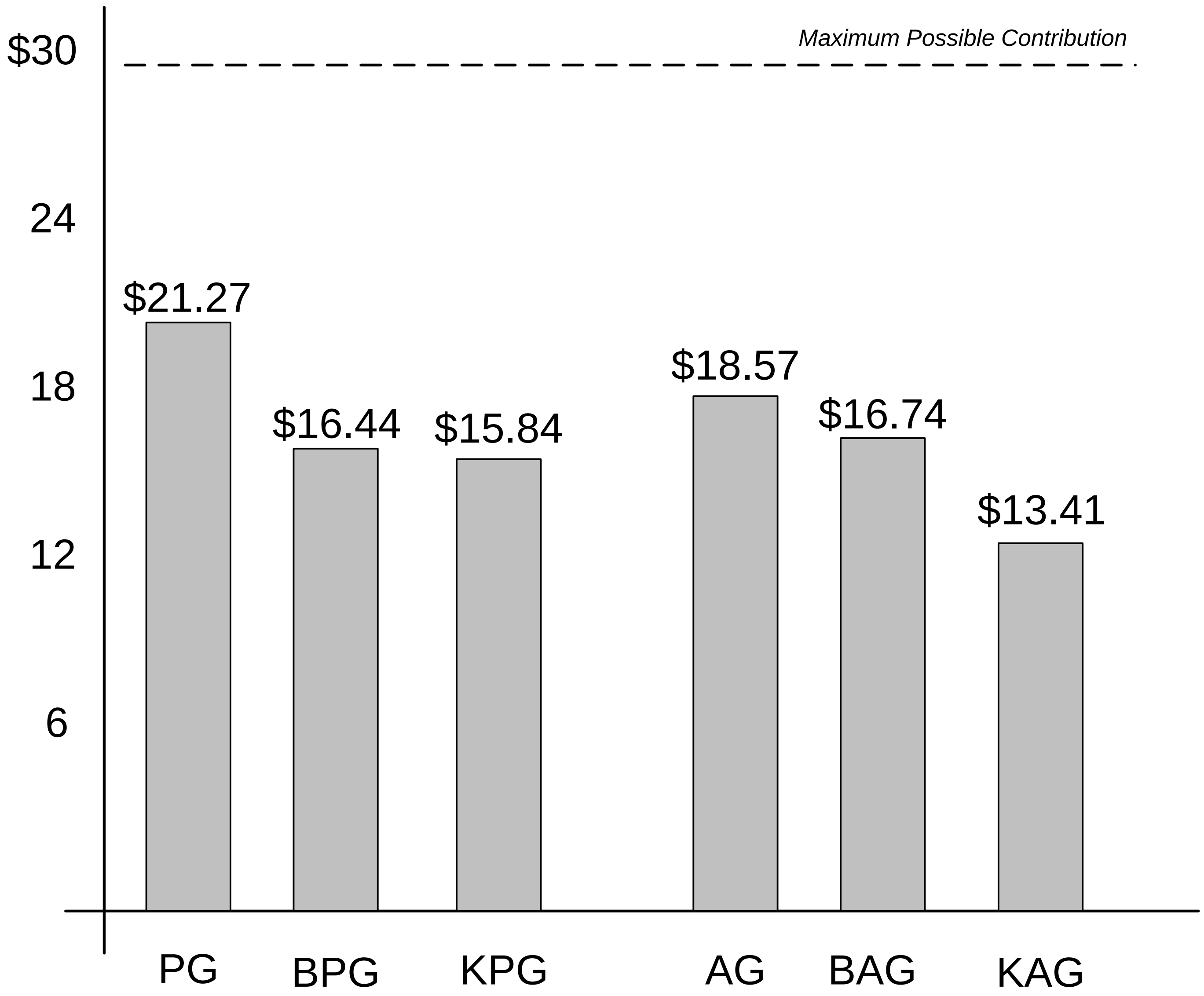
Result 2: Average earnings are lower in the asymmetric power BPG and BAG treatments than in the symmetric power PG and AG treatments, and are even lower in the asymmetric power KPG and KAG treatments.

The second part of result 2 is consistent with Hypothesis 4. Power asymmetries decrease efficiency (or realized surplus) in both provision and appropriation settings. Low efficiency is especially a feature of the king treatment for the appropriation setting, which is inconsistent with Hypothesis 3 but consistent with Hypothesis 5. Treatment KAG comes closest to manifesting a strong form tragedy of the commons.

Result 3: Pooling across decision groups (n=70), least squares analysis of total allocations to the Group Fund leads to the following results related to selective tests of equality. Group Fund differences between treatments in provision settings are statistically significant for PG vs. BPG and for PG vs. KPG. Group Fund differences between treatments in appropriation settings are significant for AG vs. KAG and for BAG vs. KAG. Group Fund differences are significantly lower for KAG than for KPG.

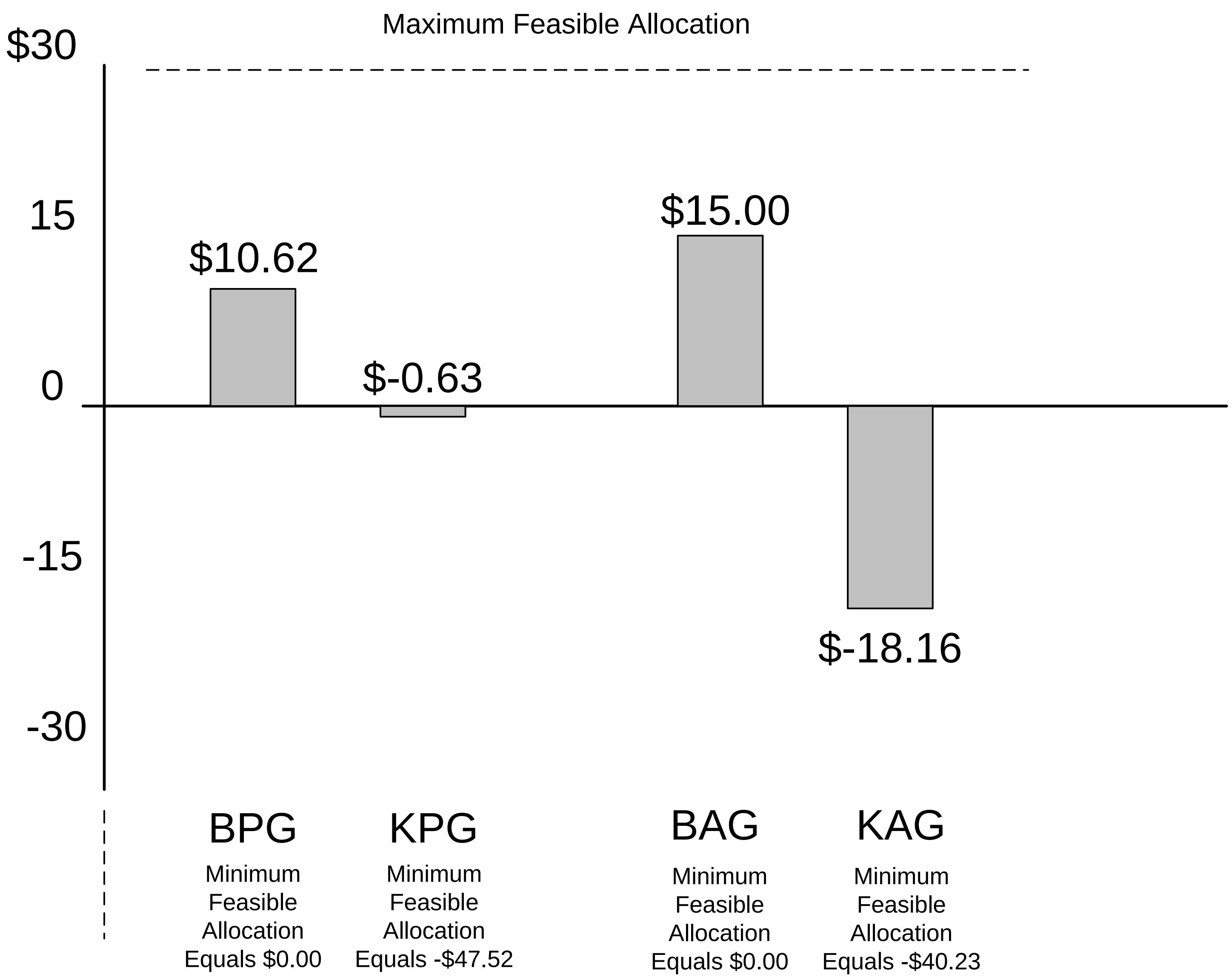
Lower allocation to the Group Fund in KAG than in BAG is consistent with (an equivalent restatement of) Hypothesis 4. Lower allocation to the Group Fund in KAG than in KPG is inconsistent with (an equivalent restatement of) Hypothesis 3.

Figure 2. Ave. First Mover Decisions Represented as $ in Group Fund



Result 4: Pooling across first mover decisions (n=227), least squares analysis of token allocations to the Group Fund (tokens left in the Group Fund) leads to the following results related to selective tests of equality. Group Fund differences between treatments in provision settings are statistically significant for PG vs. KPG. Group Fund differences between treatments in appropriation settings are significant for AG vs. KAG.

Figure 3. Ave. Sec. Mover Decisions Represented as $ in Group Fund



Result 5: Only one coefficient estimate is statistically significant, the negative coefficient for the dummy variable for the KAG treatment. The coefficient for the KPG treatment is negative but insignificant.

The significance of the coefficient for the KAG treatment is consistent with implications of reciprocal preferences, as stated in Hypothesis 5, but inconsistent with the implications of fixed preferences stated in Hypothesis 3.