CATÓLICA
CATÓLICA PORTO BUSINESS SCHOOL
PORTO

WORKING PAPERS

ECONOMICS

Nº 01/2019

SHARING RULES IN HETEROGENEOUS PARTNERSHIPS: AN EXPERIMENT

Hélia Marreiros
Universidade Católica Portuguesa, Católica Porto Business School and CEGE

Sharing Rules in Heterogeneous Partnerships: An Experiment

Hélia Marreiros
Universidade Caltolica Portuguesa,
Catolica Porto Business School and CEGE.
Rua Diogo Botelho, 1327 4169-005 Porto, Portugal
Email: hmarreiros@porto.ucp.pt.

This version: March 2017

Abstract

We experimentally investigate the welfare implications of two distinct output sharing rules in partnerships with a heterogeneous composition. In particular the paper examines the trade-off between the potential benefits of a simple equal output sharing rule and a distribution rule that maximizes total welfare, the second best sharing rule. This output sharing rule, which is recommended, is unequal in heterogeneous production groups. The experimental setup is based on a team production technology model, where Nash equilibrium contributions are located in the interior of the set of feasible contributions.

The results confirm that second best output sharing rules give higher welfare than equal ones when the two are different. Then, there is a trade off to be considered, when deciding on the team composition (the equal sharing rule is second best optimal in homogeneous partnerships), and when deciding the sharing rule given the group composition. We also find that the experimentally created wealth with equal sharing is higher than the anticipated from pure rational behavior because less skilled collaborating partners contribute with more input than anticipated. This is interpreted as evidence that less productive partners perceive a sense of unfairness when receive a similar share of output than the more productive ones, and decide to correspond with higher input contribution.

JEL classification: C92, D63, J33, M52

Keywords: Partnerships; Team Production, Incentives; Efficiency; Equality; Experiment

Financial support from the Antoni Serra Ramoneda research chair (UAB) is gratefully acknowledged. I am also grateful to Jordi Brantds, Vicente Salas Fumás and Carles Sola i Belda for their support and comments.

1. Introduction

Diverse teams produce better results"

Lew Platt, former CEO of Hewlett-Packard

The distinctive feature of partnerships is that total output produced is equally shared among all collaborating members, even though each member may contribute different amounts to total output (Farell and Schotchmer 1988). Although partnerships are common in so different activities as fishing, law firms and scholarly production, little is known about the design of efficient output sharing rules in partnerships. This paper shows the results of an experiment that compares the performance of collaborative production among individuals with different skills in two situations, with equal sharing and with an output sharing rule determined from a welfare maximizing criteria (second best). Our results show that the choice of the output sharing rule matters for productive efficiency in joint production, and that the response of collaborating partners to equal and unequal output sharing is different for high and for low skilled partners. Therefore the potential gains in fairness, simplicity and rent seeking avoidance of equal sharing rules (Farell and Schotchmer, 1988), must be balanced against the potential loss in efficiency.

The conceptual framework to study partnerships behavior in this paper is taken from the theory of self-management organization in team production technology as initially formulated by Alchian and Demsetz (1972) and Holmstrom (1982). Team production technologies are those where resource inputs are complementary in production (higher quantity of one input increases the productivity of the others) so there are potential gains from joint production over separate one. The organization design problem appears when the resources belong to different owners and information problems make impossible to compensate each resource owners according to their marginal contribution to output. In these situations the compensation of collaborating partners will be tied to the output of the group, which will result in inefficient input contributions from the point of view of welfare maximization (free riding behavior). Holmstrom (1982) showed that when the budged constraint is binding there is no output sharing rule that will implement the first best welfare maximizing solution. However, this result does not mean that all sharing rules will be equally efficient in joint production with team technologies.

In this paper we experimentally investigate if the choice of the output sharing rule matters for efficiency in production partnerships and if it matters as predicted by the theory. Namely,

if the second best sharing rule gives higher level of welfare than the equal sharing rule when the two are different.

The experiment is designed as a team production environment where individuals endowed with (simulated) different skills, high and low, decide how much to contribute to the joint production under a given output sharing rule. The joint production and team technology result from the imposed condition of complementary skills that in turn imply different marginal contribution to output and different marginal costs. The experiment has two treatments. In the first the output is shared equally amongst the members of a group of four. In the second, the output is shared accordingly to a theoretically determined second best sharing rule that assigns higher share of output to high skilled individuals than to low skilled ones. The design is stranger matching with complete information on skills (skills' differences are common knowledge) but with no information about the decision of the other subjects.

The aim is to compare group and individual decision-making on input contributions and the resulting total welfare between and within treatments. Moreover, we aim to compare the observed behavior with the Nash equilibrium solutions in a non-cooperative game. Herein, each player chooses the input contribution that maximizes individual utility, which is determined as the difference between compensation and opportunity cost. There are two Nash equilibrium solutions to compare with, the one for the equal sharing rule and the other for the second best one.

The results of the experiment confirm the prediction that self-managed organization with output sharing and balanced budged constraint generates free riding behavior in the collaborating partners. We find that the input contributions and the total wealth created from joint production are lower that the welfare maximizing ones (first best). The inefficient behavior is observed under both, equal and unequal (second best) output sharing rules. However, the loss in total welfare is lower under the second best sharing rule than in the equal sharing one, confirming that the choice of the output sharing rule matters for efficiency in self-management with team production technologies.

In terms of the observed behavior of high and low skilled individuals in the two treatments, we find that the high skilled contribute with more input than the low skilled ones under the two sharing rules. This result is in line with Nash equilibrium predictions. However, the observed contributions are above the predicted by the Nash equilibrium in the two experimental setting, equal and unequal output sharing rules. The upward deviation from the Nash equilibrium, i.e. over-contribution, is commonly observed in experiments with potential free riding behavior in nonlinear settings, where Nash equilibrium contributions are located in the interior of the set

of feasible contributions (Rapoport and Suleiman, 1993; Keser, 1996; Nalbantian and Schotter, 1997; Van Dijk et al., 2002; Sadrieh and Verbon, 2006; Irlenbusch and Ruchala, 2008).

Nonetheless, we observe that while high skilled individuals deviate in a similar amount from the Nash equilibrium solutions under the two sharing rules, the low skilled ones deviate more upwards in the equal sharing rule than in the unequal, second best, sharing rule. Low skilled individuals benefit (free ride) from the higher productivity of the high skilled ones under equal sharing and, aware of this, they seem to be compelled to contribute more than what it would be individually rational to joint production. The high skilled ones, however, appear to be unaffected by any sense of fairness when receive an equal share of output, as their over-contribution is similar in both treatments.

Furthermore, we find that input contributions are quite stable over rounds and do not convergence towards the Nash equilibrium. This result is consistent with Chan et al. (1999). However, is inconsistent with the common observed decline on contributions over rounds in public good games with both, homogeneous (see for example Fehr and Gatcher, 2000a) and heterogeneous players (see for example Buckley and Croson, 2006).

The research presented in this paper is related to the experimental literature on the determinants of the contributions to public goods in nonlinear settings. The vast majority of previous experimental literature that examined the potential free riding behavior has been focused in linear public good games of homogeneous individuals (Ledyard, 1995 surveys the results of the early public good experiments). Some studies have introduced heterogeneity in linear public games by giving subjects different endowments (Dickinson and Isaac, 1998; Buckley and Croson, 2006; Reuben and Riedl, 2013), by assuming different costs of effort (Schotter and Weigelt, 1992), or by varying the marginal incentive to contribute to the public good (Fisher et al., 1995).

Only a few experimental studies have analyzed endowment heterogeneity in nonlinear settings (Rapoport and Suleiman, 1993; Hackett et al., 1994; Ostrom et al., 1994; Chan et al., et al., 1996; Chan et al., 1999; Van Dijk et al., 2002; Sadrieh and Verbon, 2006). Each of these studies has focuses on comparing aggregated group contributions between homogenous and heterogeneous group. The experimental evidence on the benefits of heterogeneity in comparison to homogeneity is mix. While Ostrom et al. (1994) and Van Dijk et al. (2002) find that heterogeneity leads to lower contributions, Sadrieh and Verbon (2006) find no significant differences and Hackett et al., (1994), Chan et al. (1996) and Chan et al. (1999) find a positive effect of heterogeneity.

The last two studies are the closest to our study. Chan et al. (1996) find evidence that sufficiently large dispersion in endowments leads to higher aggregate contributions to the public good than a homogeneous composition. Chan et al., (1999) investigate the effect of group composition in contributions to a public good. They compare aggregate contributions between homogeneous groups, groups with single heterogeneity (with different endowments or with different payoff preferences) and groups with double heterogeneity (on endowments and on payoff preferences). They find no differences between homogeneous and single heterogeneous groups' contributions. However, the observed contributions increase when double heterogeneity is introduced in a setting with complete information on endowment and preferences' heterogeneity. To the best of our knowledge, this is the only study that introduces simultaneously different kinds of heterogeneity in a nonlinear setting. Nonetheless, the focus of their study is on the effects of group composition on contributions, under different information conditions and no analysis at the individual level is made.

Our paper is different from previous research in several ways. First we model and experimentally test the free riding behavior in an environment of self-management organization of production of a private good that may be shared in equal or in different proportions by each production partners. In public good games the good produced is consumed equally and fully by all contributing individuals. Self-management organizations, for example partnerships or workers' cooperatives, are important organization forms in production of private goods, and are viewed as alternatives to other organization forms such as the capitalist firms (Alchian and Demsetz, 1972). Therefore the paper contributes to the literature on the choice of organization forms in production for the market.

Second, the paper is the first to combine several forms of heterogeneity in team compensation experiments: heterogeneous skills that imply different marginal contributions to joint output; heterogeneous opportunity costs of inputs; and unequal sharing rules determined as a second best output sharing solution. Our experimental set up allows us to compare the differences in observed behavior under the two output sharing rules, with the differences between the theoretically predicted (Nash equilibrium) behavior under one rule and the other. This increases the power of the tests of the predictions on free riding in self-managed organizations, compared with the power of tests that compare only observed and predicted behavior.

Third, the results of the paper offer new insight into organizational design of self-managed organizations. For example, the result that equal sharing lowers the efficiency in production in self-managed organizations with heterogeneous input suppliers will have to be considered

when designing the composition of production groups. If the constraint is from choosing an equal sharing rule then there are clear incentives to homogeneous groups formation (where equal sharing is second best optimal). On the other hand, if the first condition is that the group is composed of individuals of different skills then the efficiency consideration indicates that unequal output sharing is a better option than equal sharing.

The rest of the paper is structured as follows. In Section 2 we introduce the theoretical analysis. In Section 3 the experimental design and predictions are presented. The experimental results are summarized in Section 4. Section 5 concludes.

2. A simple model of team production and self-management organization

This section presents the team production model that will be used in the experimental parameterization. Consider $N \geq 2$ inputs and the same number of input owners. Each member, indexed by $i \in \{1,2,...,n\}$, has an observable skill $q_i \in \Re^+$ and takes an unobservable and unverifiable action $a_i \in \Re^+$ in the production process. Let $a = (a_1, \dots, a_n) \in \Re^n_+$; $a_{-i} = (a_1, \dots, a_{i-1}, a_{i+1}, \dots, a_n)$; $a = (a_i, a_{-i})$ and
$q = (q_1, \dots, q_n) \in \Re^n_+$; $q_{-i} = (q_1, \dots, q_{i-1}, q_{i+1}, \dots, q_n)$; $q = (q_i, q_{-i})$.

The actions of the *N* individual agents determine a joint monetary outcome according to the production function $F : \Re^N_+ \to \Re_+$. *F* is nondecreasing, continuous, twice differentiable and concave function homogenous of degree r >0. *F* is exhaustively allocated among members according to a distributional rule *S*. Given that the direct contributions are unobservable, the compensation of member *i* must be based on the total output. Let $S_i(F)$ stands for agent *i*´s share of outcome *F*. We restrict our attention to linear sharing rules, where a sharing rule is an *n*-tuple of share functions $S=(S_1, \dots, S_n)$ which satisfies the budget balancing condition: $\sum_1^N S_i(F) = 1$, for all $F \in \Re^+$.

Let $F = F(a_1, a_2, ..., a_N)$. In this game conditional on $S_i(F)$, member *i*´s utility is defined as: $U_i = S_i(F(a)) - C_i(a_i)$, where $C_i(a_i)$ is the private monetary cost of participation in the collective action, strictly convex, twice differentiable and increasing function in a_i.

Because in teamwork the benefit of a members' action depends on the skill distribution within the team, we assume that total team output is given by[1]:

[1] The production function (F(a)) borrows Hamilton et al (2004).

$$F(a_1, a_2, ..., a_N) = \sum_{1}^{N} k_i(q_1, q_2, ..., q_N) a_i \quad (1) \qquad \text{and} \qquad \mathrm{c_i(a_i)} = \frac{a_i^2}{2q_i} \quad (2)$$

Where and q_i is set to represent member's skills and k_i is a function that aggregates the skills of team members into a measure of the productivity of member *i*. The complementary skills of team members that justify the joint production and give an output from joint production higher than the sum of individual outputs, for the same level of input a_i, is captured by the assumption that k_i is increasing in q_i, for all *i,* and $k_i(q_1,...,q_N)>k_i(q_1,,q_{N-S})$ for any subset *S* in *N*. $k_i \geq 1$ for any i[2]. Assuming $q_1 > q_2 > ... > q_N$, a higher q_i implies a lower cost to manage the same input a_i, therefore a higher q_i means $c_1(a_i) < c_2(a_i) < ... < c_n(a_i)$.

Hence, the individual utility of each input owner is given by the expression:

$$U_i = S_i(\sum_{\mathrm{i=1}}^{\mathrm{N}} k_i \, \mathrm{a}_i)) - \frac{a_i^2}{2q_i} \qquad (3)$$

Where individual *i* gains utility from her share of the total output and losses utility from the cost of participating in the collective action.

The first best, welfare maximizing solution is obtained from:

$$Max\, U = \sum_{1}^{N} k_i(q_1, q_2, ..., q_N) a_i - \sum_{i}^{N} \frac{a_i^2}{2q_i} \qquad (4)$$

The optimal solution is

$$a_i^{**} = k_i q_i , \qquad (5)$$

and a social welfare of

$$U^{**} = \frac{1}{2}\left(\sum_{1}^{N} k_i^2 q_i\right) \qquad (6)$$

Lemma 1:

Assuming $q_1 > q_2 > ... > q_N$ and $k_1(q_1,...,q_N) \geq k_2(q_1,...,q_N) \geq ... \geq k_N(q_1,...,q_N)$, the optimal effort of the more able workers (h) will be higher than the optimal effort of less able workers (l): $a_h ** > a_l **$

[2] Let $K = (k_1, ..., k_N)$, where K is symmetric in the sense that $k_i(q_1, ..., q_N) = k_{\pi(i)}(q_{\pi^{-1}(1)}, ..., q_{\pi^{-1}(N)})$ for any permutation π. Therefore, assuming, without loss of generality, that $q_1 > q_2 > ... > q_N$, then $k_1(q_1, ..., q_N) \geq k_2(q_1, ..., q_N) \geq ... \geq k_N(q_1, ..., q_N)$.

On the other hand, the Nash equilibrium solution for a self-managed team with equal sharing will result from simultaneously solving the N problems:

$$Max_{a_i} \frac{1}{N}\left(F(a_1,...,a_N)\right) - \frac{a_i^2}{2q_i} \quad , i=1,...,N \tag{7}$$

The solution to this problem is:

$$a_i^{*E} = \frac{1}{N} k_i q_i \tag{6}$$

and the social welfare:

$$U_I^{*E} = \frac{2N-1}{2N^2}\left(\sum_i^N k_i^2 q_i\right) \tag{8}$$

Finally, the second best sharing rule is obtained from solving the two-stage problem:

$$\begin{aligned} &Max_{S_i} U(a_i(S_1...S_N)...,a_N(S_1,...S_N)) \\ &Subjectto \sum_i S_i = 1 \end{aligned} \tag{9}$$

Where $a_i(S_{1,\ldots,}S_N)$ is the Nash equilibrium solution from:

$$Max_{a_i} S_i\left(F(a_1,...,a_N)\right) - \frac{a_i^2}{2q_i} \quad i=1,...N \tag{10}$$

The solution to this problem is:

$$a_i^* = S_i k_i q_i \tag{11}$$

And the Second best is:

$$S_i^* = \frac{k_i^2 q_i}{\sum_i k_i^2 q_i} \tag{12}$$

Lemma 2: *The second best sharing rule is non-decreasing on skills.*

Assuming $q_1 > q_2 > ... > q_N$ and $k_1(q_1,...,q_N) \geq k_2(q_1,...,q_N) \geq ... \geq k_N(q_1,...,q_N)$, the second best sharing rule under heterogeneous agents *is proportional to members' skills.* Therefore, it implies a higher share of the output to the more able worker (h) than to the less able one (l): $S_h^* > S_l^*$.

According to the utilitarianism principle, this sharing rule is the more equitable. Note that equal output sharing is second best optimal only if all inputs have similar skills.

The equilibrium effort under the second best optimal sharing rule is:

$$a_i^{*SB} = \frac{k_i^3 q_i^2}{\sum_i k_i^2 q_i} \qquad (13)$$

and the social welfare:

$$UT^{*SB} = \sum_i^N \frac{k_i^4 q_i^2}{\sum_i^N k_i^2 q_i} - \frac{1}{2}\sum_i \frac{k_i^6 q_i^3}{(\sum_i^N k_i^2 q_i)^2} \qquad (14)$$

The previous results are summarized in the following proposition:

Propositions

1. Self-managed teams with output sharing and budged constraint imply free riding and inefficient inputs allocation in both equal sharing and second best sharing rules: $a_i^{*E} < a_i^{**}$, $a_i^{*SB} < a_i^{**}$;
2. If $S_i^* > 1/N$ then $a_i^{*SB} < a_i^{E*}$ and $U_i^{*SB} < U_i^{*E}$. If $S_i^* < 1/N$ then $a_i^{*SB} > a_i^{E*}$ and $U_i^{*SB} > U_i^{*E}$ (For prove see appendix A)
3. Inefficiency is higher under equal sharing than under second best rules: $U^{*E} < U^{*SB} < U^{**}$. (For prove see appendix A)
4. Equal output sharing is second best optimal iff all inputs have similar skills: $a_i^{*E} = a_i^{*SB}$ iff $q_i = q_j$ for all i and j.

In the following section we use these results as theoretical benchmarks for comparing the results from experiments that try to reproduce the environment of effort provision in a self-managed organization where joint production takes place under team production.

3. Experimental design and predictions

The experiment is designed as a non-real effort experiment[3] and involves groups of four people that individually and simultaneously decide how much effort a_i contribute to the joint production. The aim is to investigate if individuals and groups behave accordingly to the theoretical predictions. Therefore, the experimental design includes two treatments: The *Equal*

[3] Non-real effort experiments allow controlling for purely strategic aspects. Real effort experiments can bring the effect of intrinsic motivations that can crowd out the extrinsic motivations (see for example Fehr and Rockenback (2003); Fehr and Gachter (2000) and Gneezy (2005)).

treatment and the Proportional treatment. In the first all members receive the same percentage of the total team output. In the *Proportional treatment* the share of total output corresponds to the second best sharing rule.

The production technology and the opportunity cost functions are as described in the previous section with the team production component of the technology, $k_i(\ )$ given by the following expression:

$$k_i(q_1,...q_N) = q_i^{1/2}\left(\Pi q_i^{1/4}\right),\ q_i>1 \qquad (15)$$

Individuals 1 and 2 are high ability types and individuals 3 and 4 are low ability types. We fix the values q_{high}=10 and q_{low}=5 along all the experiment. In the equal treatment, all members receive the same share of total output: $S_i=1/4$ and in the proportional treatment the share members receive are the second best sharing rule (equation 12): $S_i^H=0.40$ for each of the high ability individual and $S_i^L=0.10$ for each low ability subject. Table 1 summarizes the values of the experimental parameters under the assumptions above. Table 2 gives the optimal and equilibrium solutions for wealth maximization and Nash equilibrium solutions for each treatment, equal and proportional shares. Our hypotheses are according to the propositions of the model and are therefore based on the theoretical predictions reported in table 2.

Table 1: Experimental parameters

Parameters	
Skill of high types Skill of low types	10 5
k (value of number) high types k (value of number) low types	22 16
Cost high Cost low	$a_i^2/20$ $a_i^2/10$
Proportional share (SB) - high ability Proportional share (SB) - low ability	40% 10%
Equal share	25%

Some comments on the structure of the game are in order. Fist we consider that it is important to design the experiment based on an economic model that explains team problematic. A common way to design experiments based on team models with interior Nash equilibrium are non-real effort experiments (Nabantian and Schotter, 1997, Irlenbusch and Ruchala, 2008). However, most of these experiments, aside from focusing in homogeneous subjects, use production functions where the output is given by the sum of efforts multiplied by a common factor and do not consider the theoretical aspect that team production requires complementarities that lead individuals to a higher outcome by working in teams than by

working alone. As it could be difficult to replicate effort complementarities in experiments, we opt by use complementary abilities.

Table 2 – Theoretical model predictions

	Treatments	
Predictions	*Proportional*	*Equal*
Nash Equilibrium effort		
High ability	88	55
Low ability	8	20
Individual payoffs		
High ability	1297	627
Low ability	417	744
Team net payoff	3428	2743
Pareto equilibrium effort		
High ability	220	
Low ability	80	
Team net payoff	6250	

The choice of parameters was motivated by the following considerations. Being our goal to understand team problematic with heterogeneous agents, we differentiate subjects by attribute them different abilities. This translates into different values on subjects' effort, which also replicate the abilities complementarities, and in different costs for performing the same level of effort. Some previous experiments in public good games that focus on heterogeneity give subjects different endowments (Buckley and Croson, 2006; Dickinson and Isaac, 1998) and others use different costs of effort (Schotter and Weigelt, 1992; Keser and Montmarquette, 2004). We opt by doing both to be consistent with the team production model. Moreover, accordingly to human capital theory (Becker, 1964; Mincer, 1974) those who have more abilities have lower costs to perform the same level of effort. This theory explains differences in the compensation of workers as a result of differences in their observed ability. We opt by differentiate members with the double of ability, which lead to a considerable difference in the abilities' complementarity function (k_i), in the cost function and in second best sharing rule. According to Bergstrom et al. (1986) model and Chan et al. (1999) empirical evidence, just sufficiently large different distributions can affect contributions in public good games. As the aim of this experiment is to study cooperation in behavior, we want to insure a sufficient large distribution in the proportional treatment.

Implementation:

We recruited 48 undergraduate students from Universitat Autonoma de Barcelona using online recruitment system (ORSEE), with 24 subjects in each session. We conduct one session per treatment. The experiment was design with experimental software z-tree (Fischbacher, 1999).

Non-real effort experiments are used to avoid uncontrollable suggestive influences (Irlenbusch and Ruchala, 2008). Therefore, language was kept neutral during the experiment. Expressions like "effort" and "cost of effort" were substituted by "number" and "cost of number"; the k function was set to represent the "value of the number". "Team wealth" was referred as "result", which was described as the sum of the value of the numbers of all four members. Expressions like high and low ability types were also substituted by "type 1" and "type 2" subjects, respectively.

At the beginning of each session subjects were randomly allocated to one computer each. Printed instructions[4] were distributed and read aloud to all participants. They knew that in their group there were two members of each type and that the "number" that "type 1 (type 2)" participants chose had a higher (lower) value (k) and a lower (higher) cost than the number that "type 2 (type 1)" participants chose. Cost tables with all the possible integer numbers, corresponding values and costs for each type of participant were distributed along with the instructions. Their payoffs were explained as being a proportion of the sum of the values of the numbers chose by the four members of the group less the individual cost of own chosen number.

After calculating some examples to demonstrate their understanding of the game, the experiment starts. Subjects were randomly assigned to a team and randomly attributed "type 1" (high ability) or "type 2" (high ability). They were asked to choose a number out of the integer set $N \in [0,250]$[5]. At the end of each round subjects receive feedback on the own number chose, its value and cost, their individual payoff and the result (team wealth), however, no information about the decisions of the other participants was provided. No interaction was allowed during the experiment and no information about the identities of the subjects was given.

Subjects played first one-shot round not knowing that the experiment was going to be repeated. After finishing this one-shot round, which was treated as a learning round, participants were told that they will play the game for 10 rounds and that their earning will be

[4] Original instructions were written in Spanish. They are available upon request from the authors. A translation of the equal treatment is given in the Appendix B. Note that the proportional treatment just differs in the proportion of payoffs.
[5] From the theoretical predictions de Pareto optimum level of effort for high ability members is to choose the number of 220. Therefore we set the range of decision numbers to be from 0 to 250.

added to the final payment. In each round subjects were randomly assigned to a different group consisting of four members (stranger treatment), but their types were kept constant during the ten rounds.

After the 10th round subjects were asked to answer a post-game questionnaire. First, they fulfilled some demographic questions. Second, two questions related to distribution preferences were asked. They were given a table with three options that correspond to three distribution rules: Equal sharing (option A) - 25 percent each; Second Best (option B) – 40 percent for “type 1” and 10 percent for “type 2”; and Option C – 33 percent for “type 1” and 17 percent for “type 2” (this sharing rule is the mean of equal and second best). In the first question subjects were asked to indicate the option they preferred, in the second question they were asked to indicate the option they thought the others members of the group (type 1 and type 2) would prefer.

Each session lasted for about 60 minutes including instructions time. Subjects were paid anonymously at the end of each section and earned on average 13 Euros and a plus of 5 Euros that corresponded to a show up fee.

For statistical purposes we collect 60 independent observations for the team net payoff; 120 observations for the high ability subjects and 120 observations for the low ability subjects[6].

4. Results

4.1. Behavior under equal and proportional sharing rules: Nash comparison

Table 3 reports average efforts, their standard deviation, average payoff and average team net payoff[7] for each treatment aggregated over all 10 rounds[8]. Additionally, it reports the binomial test results on the deviations from Nash equilibrium predictions. First we find that subjects free-ride, exerting an effort lower than the Pareto optimum in both treatments (see table 2 for Pareto predictions) (binomial test, event probability=0.5, p=0.0000 for each type of player in each treatment). This result confirms our proposition 1 and support previous experimental evidence on team compensation (Nalbantian and Schotter, 1997; Irlenbusch and Ruchala, 2008).

Second, we find that both types of subjects tend to exert an effort higher than predicted in both treatments (Binomial test, event probability=0.5: Equal treatment: high ability types:

[6] The observations of high and low ability subjects are not independent and are treated as dependent observation in the statistical analysis.
[7] The average team net payoff is the total team wealth less the sum of subjects’ cost of effort.
[8] Recall that subjects played a one-shot round before the 10-rounds game. We treat this round as a learning period, thus we did not include it in the data analysis. Nonetheless, in appendix C the interested reader can find a regression analysis on effort that controls for the effect of this one shot round. Table 4 indicates that there is a positive significant effect of the learning round for low ability members.

p=0.003; low ability types: p=0.000; all: 0.007. Proportional treatment: high ability types: p=0.001; low ability types: p=0.025; all: p=738). This result is illustrated in Figure 1 and Figure 2, which depict the development of average efforts over the 10 rounds per treatments and per types of players. The over-contribution[9] result is quite common in public good games with non-linear setting with homogenous (see for example Irlenbusch and Ruchala, 2008) and heterogeneous subjects (Sadrieh and Verbon, 2006; Van Dijk et al., 2002; Rapoport and Suleiman, 1993).

Table 3: Overall results

	Average effort	SD of efforts	Average payoff	Average team net payoff
Equal sharing				3350***(2743) 0.000
High ability	78***(55) 0.003	11.13	736***(627) 0.000	
Low ability	39***(20) 0.000	5.30	939**(744) 0.046	
Aggregate	58***(38) 0.007		838***(685) 0.002	
Proportional Sharing				3617**(3428) 0.026
High ability	115***(88) 0.001	12.33	1307 (1297) 0.448	
Low ability	14**(8) 0.026	12.83	501***(417) 0.007	
Aggregate	65(48) 0.738		904(857) 0.738	

Predicted values are given in brackets.*** Significantly above the equilibrium value at 1% ** significantly above the equilibrium value at 5% * significantly above the equilibrium value at 10% (binomial test, α=0.5, two tailed)

Third, as predicted, we find that the team net payoff is lower than Pareto optimum (p=0.000 in both treatments) and higher in the proportional treatment than in the Equal treatment (Mann-Whitney test, p=0.0278). This result confirms our proposition 3 that the use of second best output sharing rules yields a higher creation of wealth and lowers inefficiency when compared to an equal split. Consequently, equal sharing is not second best when team members differ in skills, confirming our proposition 4.

[9] Contribution higher tan Nash equilibrium

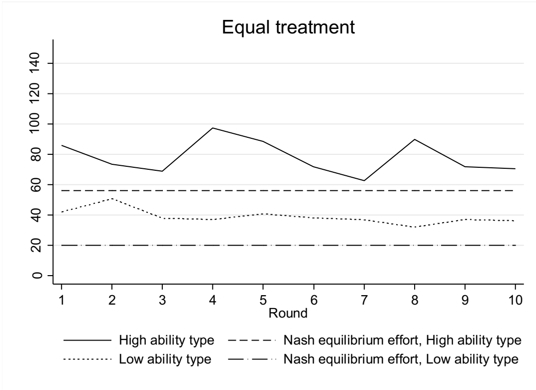

Fig. 1. Average effort – Equal treatment

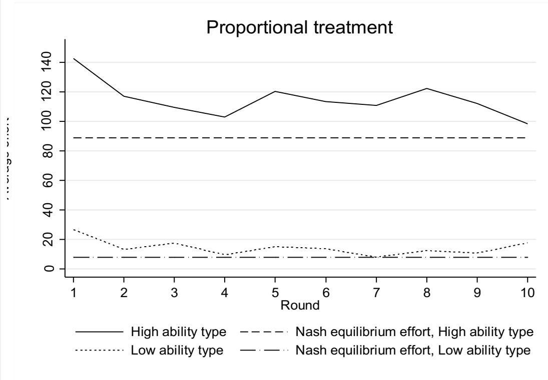

Fig. 2. Average effort – Proportional treatment

Result 1 (Free-ride and Team wealth):

I. In heterogeneous teams members tend to free-ride less than theory predicts both under an equal distributional rule and under the second best sharing rule.

II. Inefficiency is higher under equal sharing than under second best rules.

Figure 3 depicts team net payoff per treatment. As we can observe, due to the over-contribution result, team net payoff is significantly higher than predicted in both treatments (binomial test, event probability=0.5: Equal treatment: p=0.000; Proportional treatment: p=0.026). Interestingly, the difference between actual wealth created and predicted, is higher under equal sharing than under proportional sharing rule (Mann-Whitney test, p=0.0032). This result could suggest non-pecuniary rewards of an equal distribution. Next we analyze differences in treatments.

4.2. Comparison whitin and between treatments

Table 4 shows the results from an OLS data analysis. The first row contains information about the sample used. The dependent variable in the five models is the individual contribution. The explanatory variables are: a dummy representing the proportional treatment, a dummy representing the high ability types and round.

The results confirm our theoretical predictions. Whitin treatments we observe that high ability subjects contribute more than low ability subjects in both treatments, as indicated by the significant coefficient of the high ability type dummy variable in model [1], [4] and [5].

In what concerns subjects' response to the different distributional rules, we can observe an increase on contribution levels from the equal to the proportional treatment, as indicated by the significant and positive coefficient of the proportional treatment variable in model [2]. This increase is not significantly different from predicted (Wilcoxon test, p=0.5337). In contrast, as

we can see in model [3], the low ability members decrease their contribution levels from the equal to the proportional treatment. This decrease is higher than predicted (Wilcoxon test, p=0.0409). These findings confirm our proposition 4 that whenever the individual share is higher (lower) than the equal share, subjects will perform a higher (lower) effort under the second best sharing rule[10].

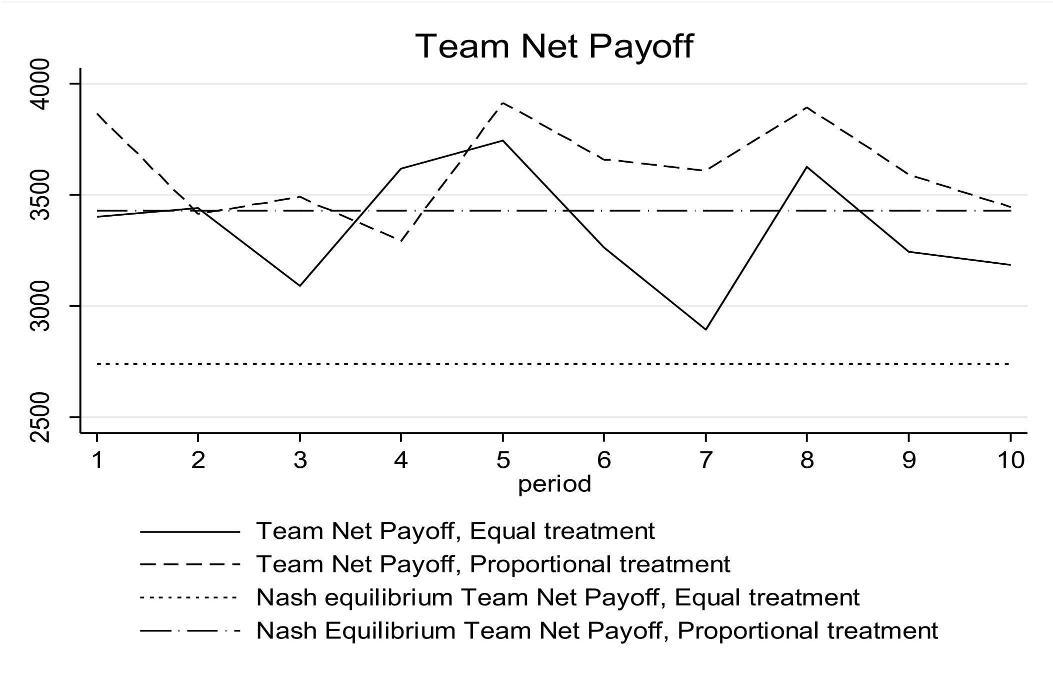

Fig 3 – Total revenue of the team by treatment

Table 4 – OLS regression results for heterogeneous teams[11].

	All Subjects [1]	*High ability Type [2]*	*Low ability Type [3]*	*Equal Treatment [4]*	*Proportional Treatment [5]*
Proportional treatment	6.23 (5.88)	36.87 (9.36)***	-24.41 (2.86)***		
High ability type	69.87 (5.01) ***			39.23 (3.14)***	100.5 (8.18)***
Round	-1.25 (0.68)	-1.57 (1.60)	-0.94 (0.33)**	-1.05 (1.04)	-1.45 (0.96)
Intercept	30.50 (7.82) ***	86.78 (9.72)***	44.10 (3.65)***	44.72 (7.30)***	22.52 (6.01)**
Observations	480	240	240	240	240
R^2	0.3455	0.0888	0.2233	0.1889	0.4994

[10]Non-parametric tests (Mann-whitney) confirm all these results at 1% level of significance.

[11] The five models in table 4 are estimated using OLS. Reported standard errors are corrected for robustness by clustering observations by group. This technique follows the approach designed by Liang and Zeger (1986). Moreover is normally used in research on public good games with stranger matching (see for example Fehr and Gachter, 2000) For results robustness we run OLS regressions without clustering for groups and GLS regressions and find similar results. For the interested reader, Table 5 in appendix C presents GLS models controlling for the one-shot round. Standard errors adjusted for group clusters are given in parentheses.***significant at 1%; **significant at 5%;*significant at 10%;

Result 2 (Individual Effort):

I. High ability members perform a higher effort than their low ability teammates under both distributional rules.

II. The use of a proportional sharing (second best) induces to an increase on effort levels of high ability members when compared to the equal sharing, but decreases low ability members' effort levels.

Most of the previous experiments with heterogeneous players do not analyze individual behavior due to methodology issues. According to Sidney Siegel (1988) the binomial test is adequate to the analysis of dependent samples. Hence, our results contribute to the discussion of individual and group behavior in heterogeneous teams.

The general result of previous experimental evidence in nonlinear public goods is that high and low endowed subjects contribute the same (Fisher at al, 1995; Buckley and Croson, 2006; Dickinson and Isaac, 1998). In fact, Buckley and Croson (2006) find that low endowed subjects contribute a higher percentage of their income than high endowment subjects. In nonlinear setting, Van Dijk et al., (2002) find the same result.

Our results are inconsistent with these findings but consistent with Chan et al.'s (1996, 1999) who find that high-endowed subjects contribute more than low endowed subjects in a nonlinear public good experiment. Nonetheless, in contrast with our findings, they find that the high-endowed subjects' contribution was manly below Nash predictions and that just low endowed subjects over-contribute.

For robustness of our results we test absolute and relative contribution in relation to Pareto optimum level of effort. The Nash prediction is that subjects should contribute the same percentage as the share they receive from the total output. Analyzing single effort choices, we find that around 20 percent of subjects choose the Nash equilibrium level of contribution. In the equal treatment, where the prediction was that both high and low skilled subjects contribute 25 percent of the Pareto optimum about 32 percent of effort choices were the predicted equilibrium. We find that on average high skilled subjects contribute 35 percent (10 percent more than predicted) and low skilled subjects contribute 49 percent of Pareto optimum (24 percent more). In the proportional treatment high skilled subjects should contribute 40 percent of Pareto optimum and low skilled just a 10 percent. We find that only 9 percent of subjects played Nash equilibrium. High skilled subjects contribute about 52 percent (12 percent more than predicted) and low skilled subjects contribute about 17 percent of Pareto optimum (7 percent more).

In absolute aggregate contributions, we find that high ability subjects over-contribute significantly more than low ability subjects. Although, the absolute over-contribution is only significant in the proportional treatment, the relative contribution is significant in both treatments (Wilcoxon sign-rank test: Absolute: all: p=0.0072; proportional treatment: p=0.0069; equal treatment: p=0.7213. Relative: all: p=0.0674; proportional treatment: p=0. 0674; equal treatment: p=0.0051).

Between treatments, we do not find differences in over-contributions (Mann-Whitney test: absolute: p=0.1517; relative: p=0.5338). By types, we find a similar absolute over-contribution of high ability types on both treatments but a higher relative over-contribution in the proportional treatment (Mann-Whitney test: absolute: p=0.5453; relative: p=0.002). We find that the low ability members over-contribute more in the equal treatment in absolute and relative terms (Mann-Whitney test: absolute: p=0.0011; relative: p=0.002).

These over-contribution results, seems to indicate some non-pecuniary benefits of working in a team. Hamilton et al, (2003) made the same suggestion. They present empirical evidence that with an equal distribution of the team output, heterogeneous groups perform better than homogeneous groups and that high ability subjects do not use their right to leave the team and work alone.

Nonetheless, the high ability subjects' over-contribution in the equal treatment and the over-contribution of low ability subjects in the proportional treatment are quite surprising. In the team technology studied in this paper, the experimental parameters were such that under an equal sharing the Nash equilibrium was a lower individual profit to the high skilled subjects than to their low ability teammates. As this constitutes another source of inefficiency, we would expect high ability subjects to under-contribute in the equal treatment, as in Chan et al, (1996,1999).

As contributions are higher than predicted but in line with the model predictions, the results on individual payoffs also follow the predicted pattern (see table 3). We find that with an equal compensation scheme, high skilled subjects have lower profits than low ability subjects (Wilcoxon sign-rank test p=0.005) mostly due to the cost of performing a higher effort and not being compensated by doing it. On the other hand, high ability types are highly compensated for exerting a high effort in the proportional treatment and achieve higher individual profits when compared to the equal treatment (Mann-Whitney test, p=0.000) and earn significantly more than the low abilities (Wilcoxon sign-rank test p=0.005). In contrast, the low ability members' free riding leads to a loss in earnings in the proportional treatment when compared to the equal treatment (Mann-Whitney test, p=0.000).

According to inequality aversion theories (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000) subjects could have tried to equalize payoffs, specially the high ability ones. We conjecture that if information about the other players' level of contribution were released, we would have found this type of results on the equal treatment.

Result 3 (Individual profit):

I. The use of a proportional sharing (second best) induces to an increase of high ability members' profit when compared to the equal sharing, but decreases low ability members' individual payoff.

II. Under an equal compensation scheme high ability members achieve lower individual payoffs than their low ability teammates. In contrast, under a proportional sharing rule (second best) they achieve higher individual profits than the low ability members.

Comparing model [4] and model [5] in table 4, and by the visual inspection of Fig.1 and Fig.2, we can observe that in the proportional treatment there is higher dispersion on efforts than in the equal treatment (Mann-Whitney test, p=0.000). The use of the second best sharing rule increases the average effort level of high ability players in about 47 percent but decreases the low abilities' level of effort in about 64 percent when compared to the equal treatment. This dispersion effect is consistent with the model and with Chan et al., 1996. We find that in the equal treatment there is no significant differences between the predicted and actual effort dispersion between high and low ability members (Wilcoxon test, p=0.5937). In the proportional treatment we do find a higher dispersion on effort levels than predicted (Wilcoxon test, p=0.0505). Consequently, the dispersion on individual profits is also higher in the proportional treatment than in the equal treatment (Mann-Whitney test: p=0.000).

Result 4 (Dispersion): There is a lower dispersion on efforts and on individual profits with an equal sharing rule than with a proportional sharing rule (second best). Thus, the higher the dispersion in rewards is, higher the dispersion in contributions.

4.3. Trend over rounds.

Observing figures 1 and 2 it is not clear if contributions decrease over time, as it generally observed in public good experiments.12 It is therefore interesting to have a look at the changes of behavior over rounds. From table 4, we can observe that average contribution is generally stable over rounds13, as indicated by the non-significant coefficient of the variable round at the aggregate level (model [1]) and in both treatments (model [4] and [5]). Nonetheless, we observe differences between types. While the high ability subjects maintain their effort level quite constant over rounds (model [2]), the low ability members slightly decrease contributions over time (model [3]).

Result 5 (Trend):

I. In teams composed by heterogeneous input owners, aggregated contributions do not decrease over rounds.

II. At the individual level, while the high skilled subjects' average contribution is quite stable over rounds, the low skilled subjects' contribution level slightly decreases.

This is a quite different result from the majority of public good games where contributions convert to free-riding over time with both homogenous (see for example Fehr and Gachter, 2000; Irlenbusch and Ruchala, 2008) and heterogeneous players (see for example Buckley and Croson, 2006).

However, just some of the few studies with heterogeneous subjects in nonlinear settings have analyzed trend over rounds. Our results are consistent with Chan et al., 1999, who find that with heterogeneous players (both single and double heterogeneity) and partner matching, average contributions were quite stable, however, near or below Nash equilibrium. Additionally, from the visual inspection of Chan et al., 1996, it seems that average contributions do not decrease over time, however, there is no statistical support. On the other hand, it is quite common to find stability on contributions over rounds, when introducing bonus or prizes (Irlenbusch and Ruchala, 2008; Sutter 2006, Dickinson and Isaac, 1998) communication (Issac et al. 1988) or punishment (Reuben and Riedl, 2013).

Hence, we conjecture that heterogeneity combined with complete information and stranger matching originate stability over rounds.

---

[12] This trend is also typically observed in public good games (see Ledyard, 1995 for a survey on experiments on public good games) both when subjects have symmetric and asymmetric endowments (Dickinson and Isaac, 1998; Buckley and Croson, 2006).

[13] We also calculated the average Pearson correlation coefficient between round numbers and average contributions. The Binomial test shows that the Pearson correlation coefficients in not significantly more often negative than positive in none of the models (event probability α=0.5, p>0.453).

4.4. Post-experimental questionnaire: Preferred sharing rule

After inform subjects about their individual profit in the experiment. Subjects were told that the experiment was over and asked to answer two questions about preferences for distributional rules. They were given a table with three options that correspond to three distribution rules: Equal sharing (option A) - 25%; Second Best (option B) – 40% for "type 1" and 10% for "type 2"; and Median sharing (option C) – 33% for "type 1" and 17% for "type 2" (this sharing rule is the mean of equal and second best). In the first question subjects were asked to indicate the option they preferred, knowing their type (the same type they were attributed during the experiment). In the second question they were asked to indicate the option they thought the other members of the group (type 1 and type 2) would prefer.

We find significant differences between treatments[14]. After playing the equal treatment 67 percent of the high ability subjects indicated they prefer the proportional sharing rule and 8 percent showed preferences for the median share. They thought that only 50 percent of the other high ability subjects and 8 percent of the low ability subjects would choose that compensation scheme. In fact, none of the low ability subjects chose the proportional share. We find that 83 percent chose the equal share and 17 percent chose the median share. They believed that 92 percent of the high ability subjects would choose the proportional share and that none of their low ability teammates would choose this distributional rule.

After playing the proportional treatment the percentage of high ability subjects that indicate preferences for the proportional sharing was 83 percent and the remaining 17 percent chose the equal sharing. They thought that all of the other high ability subjects and none of the low ability subjects would choose the proportional sharing. In fact, 17 percent of the low ability subjects indicate preferences for this distributional rule and 8 percent for the median share. They believe that 75 percent of their high ability teammates and 8 percent of the other low abilities would choose the proportional share.

These results seem to indicate that the choice of the sharing rule was influenced by the context that subjects were playing. Note that in a context were subjects' answers were anonymous and with no implications for the other subjects, we would expect that 100 percent of subjects indicate preferences for the distribution rule that better suits their economic interests. However, after playing under a certain distributional rule, at least 17 percent of the subjects considered that sharing rule as preferable in comparison with the one that will lead

[14] Table 6ª and 6b in appendix C present these results.

then to better payoffs. This could be explained by conformity theories (Asch, 1946; Jones, 1984). The most sticking evidence of this fact is the 50 percent increase on the beliefs of high ability members about the preferred distribution rule of the other high ability subjects from the equal to the proportional treatment. Experiencing an equal environment could influence preferences and decisions on distribution rules.

5. Conclusion and discussion

We experimentally investigate the inefficiency of an equal distributional rule on partnerships composed by input owners of heterogeneous skills. We report the results of a non-real effort experiment, based on a theoretical model of team production. The experimental design includes two treatments, the Equal and the Proportional treatment. In the first treatment, the total team output is equally distributed amongst all members of the group. In the second treatment, the distribution of total output corresponds to the second best sharing rule, which involves paying a higher share of the total output produced to the more skilled subjects.

Our results are in line with the theoretical predictions and support the model's propositions. First, we find that subjects do free-ride, although less than predicted in both treatments. Second, we find that the use of an unequal sharing rule, increase team net payoff when compared to an equal distribution. Hence, in heterogeneous partnerships, equal sharing is not second best and brings inefficiency to the team. Third, at the individual level, we find that whenever the individual share is higher (lower) than the equal share, subjects will perform a higher (lower) effort under the second best sharing rule.

We also find that high skilled subjects contribute more than low skilled participants in all treatments, both in absolute and in relative (percentage of Pareto level of contribution) terms. As predicted, this leads to a lower profit than their low ability teammates in the equal sharing, which constitutes another source of inefficiency of the equal sharing. As in Chen et al, 1999, we do not find a significant decrease of contributions over rounds. We conjecture that this stability was to some extent due to the double heterogeneity and stranger matching design, but mostly due to the lack of information about the contribution level of other members of the group. It could be interesting to study subjects' reaction when that information is released in a partner matching design. According to inequality aversion theories (Fehr and Schmidt, 1999), subjects tend to equalize payoffs, thus, we conjecture that if this theory is true, contributions would decrease over rounds until an equalization of payoffs is reached.

Furthermore, our results indicate that while the high skilled subjects' over-contribution is similar in both treatments, the low skilled subjects over-contribute more in the equal sharing. This leads to a higher difference between actual and predicted wealth created in the equal treatment than in the proportional treatment. These findings seem to indicate that the use of equal sharing rules could lead to nonpecuniary rewards in heterogeneous teams.

In summary, from an efficient point of view, our results highly recommend the use of unequal sharing rules in self-manage teams and partnerships. However, from a practical point of view it is advised some careful in implementing this kind of sharing rules, as we find that higher the dispersion in rewards, also higher the dispersion in efforts. A very unequal sharing rule, highly decrease the effort level of low skilled workers and significantly increases their free-riding effect. It would be interesting to study the effects of a distribution that weighs equal and second best sharing rules, as option C in the post-game questionnaire. We conjecture that this type of sharing rules could increase team efficiency as it takes in account the individual interest of both types of subjects.

In the post-game questionnaire, this sharing rule (option C) was the less chosen. The high skilled subjects indicate preferences for the second best and the low skilled ones, preferences for the equal sharing. However, in this questionnaire, subjects' decisions did not have an effect in others' payoffs. An Interesting venue for future research would be to study how heterogeneous subjects decide the distributional rule. Would they prefer an equal distribution, or an efficient one, given by the second best solution? Or maybe option C will be preferred when individual decisions affect other subjects. Moreover, it would be interesting to analyze the effects of that preferences on effort decisions,

References

Alchian, A., Demsetz. H. (1972). Production, Information Costs, and Economic Organization. *American Economic Review*, 62(5), 777-795.

Asch, S., 1946. "Forming Impression of Personality", Journal of Abnormal Psychology, 41: 258-290

Bolton, G. E., Ockenfels, A., (2000), "ERC: A theory of Equity, Reciprocity and Competition." American Economic Review, 90(1), pp. 166-183.

Buckley, E., R Croson, (2006), "Income and wealth heterogeneity in the voluntary provision of linear public goods." Journal of Public Economics 90 (4), 935-955

Chan, Kenneth S., Mestelman, Stuart, Moir, Rob, Muller, R. Andrew, 1996. The voluntary provision of public goods under varying income distributions. Canadian Journal of Economics 96, 54– 69.

Chan, Kenneth S., Mestelman, Stuart, Moir, Rob, Muller, R. Andrew, 1999. Heterogeneity and the voluntary provision of public goods. Experimental Economics 2 (1), 5 –30.

Dickinson, D. L., Isaac, R. M. (1998). Absolute and relative rewards for individuals in team production. *Managerial and decision economics*, 19, 299-310.

Farrell, J., Scotchmer, S. (1988). Partnerships. *The Quarterly Journal of Economics*, 103(2), 279-297.

Fehr, E., Gachter, S. (2000a). Cooperation and Punishment in Public Goods Experiments. *American Economic Review*, 90(4), 980-994.

Fehr, E., Gächter, S., (2000b). Do Incentive Contracts Crowd Out Voluntary Cooperation? Working Paper, vol. 34.University of Zürich.

Fehr, E., Rockenbach, B., 2003. Detrimental Effects of Sanctions on Human Altruism. Nature 422, 137–140.

Fehr, E., Schmidt, K. (1999), "A theory of fairness, Competition and Cooperation", Quarterly Journal of Economics, 114, pp. 817-868.

Fischbacher, U. (1999), in press. z-Tree: Zurich Toolbox for ready-made economic experiments. Experimental Economics.

Fisher, Joseph, Isaac, R. Mark, Schatzberg, Jeffrey W., Walker, James M., 1995. Heterogeneous demand for public goods: behavior in the voluntary contributions mechanism. Public Choice 85, 249– 266.

Hackett, Steven, Schlager, Edella, Walker, James, 1994. The role of communication in resolving commons dilemmas: experimental evidence with heterogeneous appropriators. Journal of Environmental Economics and Management 27 (2), 99– 126.

Hamilton, B.H., Nickerson, J.A., Owan, H., (2003), "Team Incentives and Worker Heterogeneity: An Empirical Analysis of the Impact of Teams on Productivity and Participation.", Journal of Political Economics, 111(3), pp. 465-497.

Hamilton, B.H., Nickerson, J.A., Owan, H. (2004). Diversity and productivity in production teams. Working paper.

Holmstrom, B. (1982). Moral Hazard in Teams. *The Bell Journal of Economics*, 13(2), 324-340.

Isaac, R. Mark, Walker, James M., (1988). Communication and free-riding behavior: the voluntary contribution mechanism. Economic Inquiry 26, 585– 608.

Jones, S., 1984. "The Economics of Conformism", Oxford: Basil Blackwell

Gneezy, U., (2005). The W Effect of Incentives. Working Paper, University of Chicago.

Irlenbusch, B., Ruchala, G. K. (2008). Relative rewards within team-based compensation. *Labour Economics*, 15, 141-167.

Keser, C., (1996). Voluntary Contribution to Public Good when Partial Contribution Is a Dominant Strategy. Economic Letters 50, 359–366.

Keser, C., Montmarquette, C., (2007). Voluntary teaming and effort (No. 745). Discussion papers // German Institute for Economic Research.

Ledyard, J., (1995). Public goods: a survey of experimental research. In: Kagel, John, Roth (Eds.), Handbook of Experimental Economics. Princeton University Press, Princeton, NJ, pp. 111– 194.

Liang, K. Y., & Zeger, S. (1986). Longitudinal data analysis using generalized linear models. Biometrika, 73, 13–22.

Nalbantian, H.R., Schotter, A. (1997). Productivity under group incentives: An experimental study. American Economic Review, 87(3), 314-341.

Ostrom, Elinor, Gardner, Roy, Walker, James, 1994. Rules, Games, and Common-pool Resources. University of Michigan Press, Ann Arbor.

Rapoport, Amnon, Suleiman, Ramzi, 1993. Incremental contribution in step-level public goods games with asymmetric players. Organizational Behavior and Human Decision Processes 55, 171– 194.

Reuben, E. and A. Riedl (2013). Enforcement of Contribution Norms in Public Good Games with Heterogeneous Populations. Games and Economic Behavior 77: 122-137.

Sadrieh, A., Verbon, H., 2006. Inequality, cooperation, and growth: An experimental study. Europ. Econ. Rev. 50, 1197–1222.

Schotter, A., Weigelt, K., (1992). "Asymmetric Tournaments, Equal Opportunity Laws, and Affirmative Action: Some Experimental Results," The Quarterly Journal of Economics, 107(2), pp 511-39.

Siegel, Sidney; Castellan, N. John. Non parametric statistics for the behavioral sciences, McGraw-hill international editions, 1988, Second edition.

Sutter, M. (2006). Endogenous versus exogenous allocation of prizes in teams – Theory and experiment evidence. Labour Economics, 13(5), 519-549

Van Dijk, F., Sonnemans, J., van Winden, F., 2002. Social ties in a public good experiment. J. Public Econ. 85, 275–299.

Appendix

A. Model

Prove of proposition 2:

From Lemma 2 we infer that the second best sharing rule is nondecreasing in abilities. Assuming that $q_1 > q_2 > ... > q_N$, this distribution rule gives a higher share of the output to the more productive worker and lower to a less productive one, therefore the high ability member will be better off with the second best sharing rule, opposite to low ability members. Mathematically we have:

Member's individual utility with the second best sharing rule is given by:

$$U_i s = \frac{(k_i\, a_i **)^3 \left[2\sum_{i=1}^{N} (k_i\, a_i **)^2 - 1 \right]}{2(F(a**))^2} \qquad \text{(a)}$$

Member's individual utility with the equal distribution is given by:

$$U_i e = \frac{2\sum_{i=1}^{N} (k_i\, a_i **) - (k_i\, a_i **)}{2N^2} \qquad \text{(b)}$$

Hence, for $k_i\, a_i ** > \frac{F(a**)}{N}$, $a_i s* > a_i eq *$ *and* $U_i s > U_i eq$.

When the collaborative efficient effort of individual i is higher than the mean of the efficient production he will be better off in the second best sharing rule. High ability members will do a higher effort in the second best sharing rule and will be better off in under this sharing rule, opposite to low ability members that will do a high effort in the equal sharing rule and will be better off under this sharing rule.

Prove of proposition 3:

The team welfare in the second best sharing rule is given by:

$$UT^S = \sum_{i=1}^{N} \frac{(k_i\, a_i **)^2}{F(a**)} - \sum_{i=1}^{N} \frac{(k_i\, a_i **)^3}{2\left(F(a**)\right)^2} \qquad \text{(c)}$$

And the welfare of the team with the equal sharing rule is given by:

$$UT^{eq} = \sum_{i=1}^{N} \frac{(2N-1)}{2N^2} k_i\, a_i ** \qquad \text{(d)}$$

Hence:

$$\frac{\sum_{i=1}^{N} \frac{2(k_i\, a_i **)^2 F(a**) - (k_i\, a_i **)^3}{2(F(a**))^2}}{\sum_{i=1}^{N} \frac{2Nk_i\, a_i ** - k_i\, a_i **}{2N^2}} > 1 \qquad \text{(e)}$$

Therefore, *UTs>UTeq*, when $N * k_i a_i > F(a**)$.

Whenever there is dispersion on abilities, the proportional sharing rule increases the total welfare of the team.

B. Instructions Equal Treatment

You have been asked to participate in a study that analysis group decision making. During the experiment we will speak in terms of Experimental Monetary Units (EMUs) instead of Euros. Each participant will receive an initial endowment in EMU. You may earn an additional amount of money depending on your decisions in the experiment. Your payoffs will be calculated in terms of EMUs and then converted to euros at the end of the experiment at a rate of 800 EMUs = 1 Euro. This money will be paid to you, in cash, at the end of the experiment. You will be given a set of instructions that will be read aloud to all participants. If you have any question, please raise your hand and one of the experimenters will go to you and your question will be solved.

The decision situation:

At the beginning of the experiment you and three other participants will be randomly assigned to your group. The identity of the other participants will not be revealed and you cannot interact with the other members of the group.

In your group there are two participants that will be called of type 1, and two participants of type 2. You will be random selected to be a type 1 or a type 2. You will know your type but will not know who is the other person that share your type or who are of the other type. You and the other three subjects of the group must choose a number between 0 and 250 without knowing the decisions of the other members of the group.

The election of this number has some implications. The number you choose will have a different value depending on your type: if you are type 1 the value of the number is the chosen number multiplied by 16 and if you are type 2 is the chosen number multiplied by 16 (see table k*number). The values of the chosen numbers off the four members of the group are add and each one of the members receives a percentage of that sum, in concrete each one will receive 25% of the sum of the value of the chosen numbers.

On the other hand your chosen number causes a certain cost. As mentioned there are two types of participants in your group. Each type of participant has different cost associated to each possible number that you chose. This means that the type 1 participants have a cost for the chosen number that is equal among them but different of the cost that type 2 participants have for this number. **The cost of the number that you chose will be deducted directly of your payoff.**

In the moment that the experiment starts you will know which type of participant you are in the group and you can consult the cost table in the annex. In this table you can see the value and the cost that each number has for your type and for the other type.

You can also see that each number has a different cost. For the type 1 members the cost of the number is equal to the square of the chosen number divided by 20, while for the type 2 members it is equal to the square of the chosen number divided by 10.

In the next table you can see an example of how to reed the table.

Example Cost Table :

Type 1

K	Number	Value: (K*Number)	Cost of Number
22	2	44	0,2
22	5	110	1,3
22	15	330	11,3
22	20	440	20,0
22	50	1100	125,0
22	149	3278	1110,1

Type 2

K	Number	Value: (K*Number)	Cost of Number
16	2	32	0,4
16	5	80	2,5
16	15	240	22,5
16	20	320	40,0
16	50	800	250,0
16	149	2384	2220,0

You can read your cost table by looking down the second column where you can find the decision numbers; the third column informs you of the value of this number and in the forth column you can check the cost of this number. For example, if you are type 1 and choose the number 15, the value of this number is 330 and has a cost of 11.3, while if you are type 2 and choose the number 15, the value of this number is 240 and has a cost of 22.5. Note that the higher the number you choose the higher its cost.

In resume your payoff in EMU if you are a type 1 participant it can be calculated by the following formula:

Payoff type 1 = 0.25*(sum of the value of chosen numbers) – individual cost type 1

While if you are a type 2 participant, your payoff in EMU will be:
Payoff type 2 = 0.25*(sum of the value of chosen numbers) – individual cost type 2

Example of how your earning will be determined:
If, for example, you are a type 1 member and choose the number 20, your number has a value of 440. If each of the other members of the group chose a number of 15, one number (of the other type 1 participant) will have the value of 330 and the other two numbers will have a value of 240 (for the type 2 participants), therefore the total result is 440+330+240+240=1250 EMUs. The cost of your chosen number is 20. As every member of the group receives the same proportion of the total result (25%), your payoff will be: 0.25*1250-20= 292.5 EMU

Comprehension questionnaire:

A. Suppose that you are a type 2 member and choose a number of 5, the value of your number is _______ and the cost of your chosen number is _______. Suppose that the other type 2 member have chosen the number 50 and each of the type 1 members have chosen the number 20, the total result is _________, and thus your payoff is ____________.

B. Suppose that you are a type 1 member and choose a number of 2, the value of your number is _________ and the cost of your chosen number is _______. Suppose that the other type 1 member has chosen the number 149, one of the type 2 members has chosen the number of 5 and the other has chosen the number of 50, the total result is _________, thus your payoff is____________.

The experiment:

The experiment includes the decision situation just described to you. You will be paid at the end of the experiment based on the decisions you make in this experiment.

After the instructions are read aloud and all the participants have understood, the experiment will start. You will see the first screen where should insert you ID number in the correspondent field. In the next screen you will be asked to insert a number between 0 and 250 in the correspondent field, if you press OK you can see the value and cost of the number as long as the proportion (25%) of the value of your number that you will receive. You can use the help screen to make simulations en relation to the number you can choose and the number that the other could choose. As you don't know which number the other will choose, you can simulate typing a number between 0 and 250 in the correspondent field. If you click "calculate" you can see the value and cost of each of these numbers accordingly to the correspondent member. You can also see the final result of your simulation when click " see calculations". At the bottom of the screen you can see the sum of the value of the numbers that you simulate as long as the proportions that you could receive from this sum, the cost of your number and the final payoff (EMU) of the simulation. If you click "change decision" you turn to the decision screen. Your decision will be validate when you press the "continue" button. In the next screen you will know your payoff (EMU)

Thank you for your participation. After finishing the experiment please wait for payment instructions.

C. Other tables

Table 5 – OLS regression results for heterogeneous teams

	All Subjects [1]	*High ability Type [2]*	*Low ability Type [3]*	*Equal Treatment [4]*	*Proportional Treatment [5]*
Proportional treatment	6.59 (4.28)	34.77 (7.52)***	-21.58 (3.24)***		
High ability type	67.44 (4.28) ***			39.27 (5.20)***	100.5 (6.56)***
Round	-1.25 (0.78)	-1.57 (1.37)	-0.94 (0.59)	-1.05 (0.95)	-1.45 (1.14)
One-shot Round	3.34 (8.60)	-11.75 (15.10)	18.43 (6.50)***	2.46 (10.44)	4.22 (12.80)
Intercept	31.54 (5.72) ***	87.83 (9.31)***	42.69 (4.30)***	44.70 (6.45)***	223.54 (12.12)***
Observations	528	240	240	240	240
R^2 Overall	0.3277	0.0888	0.2233	0.1889	0.4994

The dependent variable is effort. Standard errors adjusted for group clusters are given in parentheses.***significant at 1%; **significant at 5%;*significant at 10%;

Table 6a – Distributional rules choices after treatment

Type	Choice: Proportional Share	Equal Share	Median Share
High abilities			
Equal treatment	67%	25%	8%
Proportional treatment	83%	17%	0%
Low abilities			
Equal treatment	0%	83%	17%
Proportional treatment	17%	75%	8%
All members			
Equal treatment	33%	54%	13%
Proportional treatment	50%	46%	4%

Table 6b – Believes on the other members' choice (relation to proportional share)

	Other High ability members	Other Low ability members
High ability members		
Equal treatment	50%	8%
Proportional treatment	100%	0%
Low ability members		
Equal treatment	92%	0%
Proportional treatment	75%	8%