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Treating Equals Unequally - Incentives in Teams, Workers' Motivation and Production Technology

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Treating Equals Unequally - Incentives in Teams, Workers' Motivation and Production Technology

by

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December 2007

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Treating Equals Unequally –

Incentives in Teams, Workers' Motivation and Production Technology[†]

Sebastian Goerg[‡‡], Sebastian Kube[*], Ro'i Zultan[**]

December 4, 2007

Abstract

The importance of fair and equal treatment of workers is at the heart of the debate in organizational management. In this regard, we study how reward mechanisms and production technologies affect effort provision in teams. Our experimental results demonstrate that unequal rewards can potentially increase productivity by facilitating coordination, and that the effect strongly interacts with the exact shape of the production function. Taken together, our data highlight the relevance of the production function for organization construction and suggest that equal treatment of equals is neither a necessary nor a sufficient prerequisite for eliciting high performance in teams. (98 words)

JEL classification: C92, D23, D63, J31, J33, J41, M12, M52.

Keywords: team incentives, equity, production function, social preferences, laboratory experiment, discriminating mechanism, mechanism design.

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1 Introduction

"Some contend that differentiation is nuts – bad for morale. They say that differential treatment erodes the very idea of teamwork. Not in my world. You build strong teams by treating individuals differently. ... Everybody's got to feel they have a stake in the game. But that doesn't mean everyone on the team has to be treated the same way."

Jack Welch, former chairman and CEO of General Electric[1]

A general feature of incentive schemes in organizations is a non-uniform distribution of benefits among its agents, which usually accounts for the heterogeneity in agents' ability and performance. As long as the discrimination is based on individual differences, i.e. as long as *unequal* agents are rewarded unequally, there should be little scope for fairness considerations to induce dissonance among the agents.[2] However, a recent theoretical model developed by Eyal Winter (2004) shows that it might even be optimal to treat *equal* agents unequally – depending on externalities given by the production function. This surprising result, derived under the standard assumptions of fully rational, self-centered and money-maximizing behavior, seems to stand in sharp contrast to the implications from research on fairness and equity preferences,[3] whose bottom line is that *"even a small intrinsic concern for justice, .. may have significant effects on .. wage structure"*.[4] In the present paper, we experimentally explore the interaction in teams and test within the framework of Winter's model whether the psychological cost of the inequality induced by a discriminating mechanism deters from the efficiency of the theoretical optimal mechanism. Thus, to the best of our knowledge, we report the first empirical evidence on the interplay between equity, coordination and production function within teams.

The general model as described in Winter (2004) features n risk-neutral

[1] Quote from Welch and Byrne (2001).

[2] A necessary assumption for this statement is that agents are aware of the individual differences and do not misperceive the direction of the differences; which might for example not hold true if agents are overconfident about their own performance (see Ross and Sicoly (1979) for early evidence on overconfidence about contribution to a joint project).

[3] e.g. Konow (2000), Bolton and Ockenfels (2000), Fehr and Schmidt (1999), Mowday (1991), Young (1994) or Selten (1978).

[4] Konow (2000), p. 1089.

agents who work on a project. Each agent i decides simultaneously whether to work ($e_i = 1$) or shirk ($e_i = 0$). Exerting effort is connected with costs c, with c being constant across all agents. Individual effort is assumed to be non-observable and non-contractible. Instead, agents' rewards are contingent on the success of the project, i.e. agents receive individual rewards $b = (b_1, ..., b_n)$ if the project succeeds and 0 otherwise. The probability $p(k)$ of the project's success is specified as a function of the number k of agents exerting effort, mapping the effort profiles to $[0, 1]$. In this sense, $p(k)$ can be interpreted as the project's technology or production function. We assume $p(k)$ to be strictly increasing in k. Depending on the exact specification of $p(k)$, the production function can be modeled to have increasing or decreasing returns to scale. By increasing returns to scale we mean that the production function is one of complementarity, i.e. that $p(k+1)-p(k)$ increases in k; whereas a production function of substitutability has decreasing returns to scale, i.e. $p(k+1) - p(k)$ is decreasing in k ($k \in [0, ..., n-1]$).[5]

In the following, a reward vector b is said to be strongly incentive-inducing if it induces all agents to exert effort as a unique Nash equilibrium, and it is optimal if it does so at minimal cost of rewards. The mechanism is symmetric if rewards are constant across all agents. It can be shown that such a *symmetric*, optimal, strongly incentive-inducing mechanism exists if and only if the production function is one of *substitutability*. Contrarily, a production function of *complementarity* implies the optimal, strongly incentive-inducing mechanism to be fully *discriminating* – even if all agents are perfectly symmetric![6]

The purpose of the present study is to experimentally test these key find-

[5]For the sake of simplicity we only consider the two extreme cases of increasing or decreasing returns to scale here. In general, the production function could take any form, as long as it satisfies the assumption of $p(k)$ being strictly increasing in k.

[6]Cp. Proposition 2 and 3 and the corresponding proofs in Winter (2004). Note that a technology of increasing returns to scale is a sufficient, but not a necessary, condition for full discrimination. In fact, it is only necessary that an agent's incentive to exert effort increases with the number of other agents who do so, which for example might also be caused by some psychological effect like peer pressure (cp. Kandel and Lazear (1992), Falk and Ichino (2006) or Mas and Moretti (2007) and the references therein).

ings of Winter's model, namely whether subjects' behavior is indeed sensitive to the externalities given by the production technology, and whether a major incentive advantage really exists when discriminating among perfectly identical agents; or if the psychological cost of the unequal treatment of equals drives a wedge between the initially predicted and the actually observed efficiency.

Ideally, these questions would be examined with 'cloned' workers acting in 'cloned' work environments which differ only with respect to the production function and the reward schemes. To come close to this ideal world, we introduce a simple and parsimonious laboratory experiment that allows us to analyze the interaction between production function, equity considerations, and reward scheme, while at the same time ensuring that agents are perfectly identical. In the experiment, three players work on a joint project and exert costly efforts. Their payoffs, given as reward minus cost, depend on the number of some goods produced by the joint project. Across the different treatments, the characteristics of the production function (either a function of complementarity or of substitutability) as well as of the reward scheme (either a symmetric or a discriminating mechanism) are manipulated.

We find that, as predicted by Winter's model, the subjects in our experiment respond to the shape of the production function. The discriminating reward scheme under the production function of complementarity entails almost maximum efficiency, whereas it leads to significantly lower efficiency rates under the production function of substitutability. Moreover, our data suggest that subjects' effort choices are highly sensitive to their own reward, but largely unresponsive to the rewards of the other two subjects in their group: The disadvantaged player (receiving the low reward) regularly exerts effort under the production function of complementarity, notwithstanding the unequal treatment of equals. Contrarily, the symmetric reward scheme significantly hampers efficiency, demonstrating that equal treatment of equals is not necessarily a prerequisite for eliciting high performance in teams, and that unequal treatment can facilitate coordination within the workforce.

The insights gained from our experiment are of significant importance for research on optimal mechanism design in general, but especially in the

context of work contracts and organizations. As Winter puts it: *"A large number of models in personnel economics establishes that unequal treatment of unequal agents may have major incentive advantages. The particular importance of demonstrating the optimality of treating* ***equals*** *unequally is that it potentially implies an additional gain for inequality in each of these models"* [7] We complement this assertion by ascertaining it in an empirical way.

In this regard, we contribute to the question of "equality versus inequality", which is at the heart of the debate in organizational management. Internal inequity is thought to have a tendency to lead to morale problems and to interfere with teamwork (cp. Akerlof and Yellen 1990, Milgrom and Roberts 1992, or Bewley 1999, chapter 6), whereas equal wages are usually associated with positive effects (e.g. increased peer monitoring or lower transaction costs, see Knez and Simester 2001 or Prendergast 1999). However, as Lazear (1989, p. 561) puts it, *".. it is far from obvious that pay equality has these effects."* For example, equal wages do not account for heterogeneity in agents' ability and performance, and payment is not linked to the individual's marginal product, which in turn can lead to free-riding among selfish agents (cp. Holmstrom 1982). Moreover, as we demonstrate in our setup, equal rewards make it hard to form exact beliefs about the others' effort. In contrast, the asymmetry that is created by unequal rewards has the potential to facilitate coordination within the workforce, because it reduces strategic uncertainty about each others' actions.

In real-life organizations, this discrimination is often implemented through non-monetary rewards, e.g. prestige, or by using artificial classifications or (job) titles for seemingly similar tasks, e.g. 'Project Head' or 'Team Captain'.[8] It is often hidden to avoid negative reactions of inequality-averse workers, or fixed by an internal (pay) structure. For example, lawyers, consultants and accountants are paid according to seniority. This special form of *hidden* discrimination creates common knowledge about the stakes that

[7] Winter (2004), p. 766.

[8] The 'Team Captain', as the one carrying the responsibility and possible blame for unsuccessful results, is highly motivated to exert effort. Therefore, he functions to incentivize the other team members in the same way as the high-reward agent in our model induces cooperation and high productivity. Cp. also Winter (2004), p. 769.

everyone has in the project's success, and thus fosters cooperation and coordination; while at the same time it does not invoke equity concerns because everyone knows that his turn will come to be senior partner. The experimental results in the present paper show that under a production function of complementarity even *transparent* discrimination contributes to efficiency, yet hidden discrimination is effective.

Our study differs from existing experimental studies that analyze the interaction between social preferences and reward schemes in several points. First, the evidence up to now mainly stems from bilateral gift-exchange games between a principal and a single agent.[9] What is usually observed in this setup is a positive wage-effort relationship; if the principal shares a large pie of the total output with the worker, the worker feels treated fairly and reciprocates by exerting a high effort. While this suggests that most workers care about fairness along a vertical dimension, our question about possible horizontal comparisons within the workforce is usually not addressed.[10] Second, the existing studies are mainly conducted in an incomplete-contract framework where effort and/or wage is non-contractible, while we allow for fixed contracts.[11] Third, to the best of our knowledge we are the first to pay attention to the important role of the production function. Our finding that agents' behavior is sensitive to the shape of the production function should be taken into account in future empirical research on the interaction between social preferences and reward schemes.

The remainder of this paper is organized as follows: In the next section, we describe the experimental design and derive theoretical predictions. Subsequently, the experimental results are presented and discussed in Section 3,

[9] e.g. Fehr et al. (1993, 1997).

[10] Two exceptions are notable which feature a multi-agents setup. In Charness and Kuhn (2007), two workers differ in productivity. The authors find that co-workers' wages do not matter much for agents' decisions. Contrarily, Abeler et al. (2006) demonstrate that paying equal wages to workers exerting different efforts leads to a strong decline in efficiency over time.

[11] A notable exception is Keser and Willinger (2000), where agents' actions are hidden, but wage payments can be made contingent on the observed output. However, again the focus is on the vertical comparison between a principal and a single agent. Fehr et al. (2007) provide a direct comparison on the efficiency of incomplete and fixed contracts in a bilateral setup.

and Section 4 concludes.

2 Experimental Setup

Our experiment is designed to explore the interplay between production function, monetary rewards and social preferences within a team of agents. More specifically, we check if workers' behavior is sensitive to the type of the production function that they face in their joint project. Additionally, we test for the tension between equity and efficiency in a team environment, as induced by the interaction between social (other-regarding) preferences and reward schemes.

2.1 Experimental Design

In the game we have three agents working on a joint project. Each agent individually decides whether to work or shirk, and the individual cost of exerting effort is 90 Taler[12]. In case that an agent exerts effort, the costs of 90 are deducted from his individual reward. The output of the project depends on the number of agents choosing to work, and on our first treatment variable **production function**:

	number of units produced			
prod. function	$\sum_i e_i = 0$	$\sum_i e_i = 1$	$\sum_i e_i = 2$	$\sum_i e_i = 3$
complementarity	20	40	65	100
substitutability	20	55	85	100

The first case describes a production function of *complementarity*. The technology has increasing returns to scales, since the number of produced units (the output of the project) is $p(0) = 20$ if all agents shirk, $p(1) = 40$ if two agents shirk, $p(2) = 65$ if only one agent shirks and $p(3) = 100$ if all agents work, thus $p(3) - p(2) > p(2) - p(1) > p(1) - p(0)$. In the second

[12]Taler is our experimental currency. Talers earned in the experiment were converted at a rate of 80 Taler = 1 Euro.

case, we have a production function of *substitutability*. The technology has decreasing returns to scale, since $p(3) - p(2) < p(2) - p(1) < p(1) - p(0)$.

Agents' rewards are made contingent on the output of the project, and the **reward mechanism** or remuneration scheme is our second treatment variable:[13]

	reward per unit produced		
reward mechanism	agent 1	agent 2	agent 3
symmetric	4	4	4
discriminating	3	4	5

Taken together, this leaves us with the following 2x2-treatment matrix:[14]

	complementarity	substitutability
symmetric	444COM	444SUB
discriminating	345COM	345SUB

The procedure was the same across all treatments: Upon arrival, the participants were randomly divided into groups of three. In the treatments with a discriminating reward scheme, the three possible rewards were randomly assigned within each group. The written instructions were distributed and read out aloud.[15] Afterwards, subjects could pose questions in private, and had to answer a set of computerized control questions to ensure that everybody had understood the game and to make subjects familiar with the operation of the program. Then subjects were told their own reward and the other players' rewards, and had to decide between working *normal* or working *hard*. Afterwards, it was announced that we were additionally interested in their beliefs

[13]Notice that the sum of the individual rewards does not differ across the reward mechanisms. For example, the total reward costs in case that all agents shirk equals $3(4 \cdot 20) = 240$ under the *symmetric* reward mechanism, and $3 \cdot 20 + 4 \cdot 20 + 5 \cdot 20 = 240$ under the *discriminating* reward mechanism.

[14]Actually, we did not conduct experiments on the symmetric reward mechanism under a production function of substitutability, because, as one will see in the following, it would not have added any new dimension of interest to our results.

[15]Our experiment was conducted in a labor market framing, avoiding loaded terms (e.g. 'shirk' or 'success'). The exact wording of the English translation of the instructions can be found in the appendix, and the original German instructions are available from the authors upon request.

about the other subjects' behavior, and each subject had to state what they expected the first and the second other player in their group to choose.[16] In case that their belief matched the actual behavior, subjects were paid an additional 20 Taler. Only then we announced that five additional periods of the game would follow, in which everything was kept constant (individual rewards, costs, production function and group composition). This was done to allow for possible learning to take place. After our experiment, subjects had to complete a social value orientation test (the procedure, also known as the 'ring test', is described for example in Griesinger and Livingston (1973) or Liebrand (1984); see also Beckenkamp (1995) for an early application in Economics) and a socio-economic questionnaire.

The computerized[17] experiments were run in 2007 at the BonnEconLab at the University of Bonn. For each treatment, we ran two sessions with 18 subjects each; totalling 12 independent matching groups (all periods) or 36 independent decisions (only first period) per treatment.[18] A session lasted approximately 70 minutes. Subjects were paid for their decision and their belief in the first period, and additionally for one randomly selected period (which was constant across all subjects within a session) out of the subsequent five periods. On average, subjects earned approx. 7 Euro.

2.2 Behavioral Predictions

In this section, we first derive all possible equilibria under the classical assumptions of agents being fully rational, self-centered, money-maximizing, and risk-neutral. As will be seen, the degree of efficiency, defined as the sum of agents exerting effort in equilibrium, is sensitive to the production function

[16] E.g. a player receiving a reward of 3 Taler per unit had to choose between '4' and '5' work normal, '4' and '5' work hard, '4' works hard and '5' works normal, or '4' works normal and '5' works hard. To keep the procedure constant, in 444COM we also asked separately for the behavior of the two other players in the group.

[17] The experiment was programmed in Pascal using RATimage by Abbink and Sadrieh (1995). The questionnaire and the ring test were conducted using zTree by Fischbacher (1999). Screenshots of the program can be found in the appendix.

[18] Unfortunately, in one session in treatment 444COM, only 15 subjects showed up, so that we are missing one independent observation in this treatment.

and to the reward mechanism. Subsequently, we will derive predictions for agents who are additionally motivated by equity considerations, and demonstrate how the degree of inequality of the reward mechanism should affect equilibrium behavior.

Before we start, consider that our game as described in Section 2.1 can be rewritten in a probabilistic way.[19] We instead opted for the deterministic representation to impose risk-neutrality over the final outcome of the project, i.e. to pay the expected value of a lottery rather than to actually implement the lottery. This allows us to abstract from the subjects' individual risk preferences; but for illustrative purposes we will stick to Winter's probabilistic presentation in the following derivation.

We begin with a production function of *complementarity*. To make an agent work, even if he believes that the other two agents in his group will not work, his expected payoff from working must be higher than his payoff from shirking in this situation, i.e. $b_0 \cdot 0.4 - 90 > b_0 \cdot 0.2 \Leftrightarrow b_0 > 450$. Analogously, we find that an agent will work given that he expects at least one other agent to do so if $b_1 > 360$, and given that he expects both the other agents to do so if $b_2 > 258$. Thus under the *discriminating* reward scheme, the player who receives a reward of 500 (in our specific design 5 Taler per unit produced) should always exert effort, independent of the decisions of the other two players in his group. This in turn can be anticipated by them, implying that the player who receives 400 also wants to work, independent of the decision of the third player ($400 > b_1 > b_2$). Because the player who receives 300 can expect the other two players to exert effort for sure, he also wants to exert effort ($300 > b_2$). Taken together, in equilibrium all players exert effort and expect the others to do so.

Contrarily, the *symmetric* reward mechanism does not induce all agents to exert effort as an unique equilibrium. Since everybody receives a reward of 400, no player exists who works, independent of his belief about the others'

[19] This is the interpretation used by Winter (2004). All one needs to do is to i) interpret the values of the production function not as number of units produced, but as probabilities (percentages) for having the project end successfully, ii) multiply the individual rewards by 100 and iii) let agents receive their reward only in case that the project ends successfully (and 0 otherwise).

decision ($400 < b_0$); but each player would work if he expects at least one other player to exert effort as well ($400 > b_1 > b_2$). This implies that we have two equilibria in pure strategies: Either all agents work, or all agents shirk (with all work being the payoff- and risk-dominant equilibrium). Besides that, an equilibrium in mixed strategies also exists, in which the probability of shirking is approximately 0.77 (and all players know that each of the other players will shirk with this probability).

If we switch to the production function of substitutability, first consider that a naive principal might be tempted to prefer this technology over the previous one. For a given effort sum, the chance of a project ending successfully is always equal or higher under the function of substitutability than under complementarity. However, in this case our discriminating reward scheme is not optimal anymore.[20] In equilibrium, the player receiving 300 shirks, while the players receiving 400 and 500 work; and all players hold corresponding beliefs.

To recapitulate, assuming players to be risk-neutral and strictly self-centered leads to the following equilibria in pure strategies:

production function	complementarity		substitutability
reward mechanism	symmetric	discriminating	
equilibria	$(1,1,1),(0,0,0)$	$(1,1,1)$	$(0,1,1)$

Notice that the uniqueness of the equilibrium under 345COM, and consequently the superiority of the discriminating reward mechanism over the symmetric one (444COM with the additional 'bad' equilibria), crucially depends on the assumption of subjects being self-centered money-maximizers. By contrast, part of the literature (not only) in Behavioral and Experimental Economics suggests that, beside pure money maximization, a non-negligible

[20]In fact, the total costs of an optimal, strongly incentive-inducing reward scheme are always lower under complementarity than under substitutability. With respect to this, a sophisticated principal who believes that his agents are risk-neutral money-maximizers should always try to 'design' the project in a way that workers' efforts are complements rather than substitutes – for example he might prefer a function-based technology over a process-based one.

fraction of subjects is strongly motivated by fairness considerations – i.e. subjects exhibit a basic desire for equity, including a preference for equal treatment of equals (cp. Selten (1978), Mowday (1991), Roemer (1996)), and a preference for equal payoff distributions (cp. Fehr and Schmidt (1999) or Bolton and Ockenfels (2000)). Taking this into account, the discriminating reward scheme might come at some hidden costs, which would incentivize agents to shirk under the initially incentive-inducing mechanism!

The intuition behind this argument can easily be seen, for example, if we compare the payoff distributions that a player in 345COM receiving the low reward is confronted with when he decides between working or shirking, given the belief that the other two players in his group will work: He earns a slightly higher payoff if he chooses to work (210 instead of 195), but shirking would lead to a more equitable outcome and additionally would increase his ranking within the groups' payoff distribution ($(195, 170, 235)$ instead of $(210, 310, 410)$). Consequently, a subject with preferences for equity should forego the additional payoff increase in favor of the equality increase, and shirk. Analogously, a similar subject in the role of the player receiving a reward of 5 Taler per unit should prefer to shirk if the other players do so, leaving him the highest earner in a more equitable payoff distribution of $(60, 80, 100)$, instead of being the lowest earner in a more unequal outcome $(120, 160, 110)$. In this sense, if subjects care about equity the pure equilibrium of all work under 345COM might cease to exist and might instead be replaced by an equilibrium in which all players shirk.

Under a symmetric reward mechanism, equity preferences provide additional incentives *not* to shirk: If a subject expects the other two players in his group to work, shirking will reduce his payoff and lead to a less equitable payoff distribution ($(260, 170, 170)$ instead of $(310, 310, 310)$). As a result, if subjects are motivated by equity considerations instead of being self-centered and money-maximizing, we cannot necessarily predict a lower efficiency than in the discriminating treatment anymore.

A more formal way to show how behavior and possible equilibria change once we move away from self-centered payoff-maximizing subjects, is to reconceive above equilibria derivations, now using an extended utility function

which incorporates equality preferences. To this end, we assume that subjects' preferences can be described by the model put forward by Fehr and Schmidt (1999). In their model, subjects do not care about equity or fairness per se but dislike unequal payoffs, i.e. individual utility not only depends on one's own monetary payoff, but also on the relation to the payoffs of the other persons in the group. Using their preferred parameters, $(1, 1, 1)$ and $(0, 0, 0)$ are still possible equilibrium outcomes in 444COM, but in 345COM their model not only predicts $(1, 1, 1)$ but also $(0, 0, 0)$ to be a possible outcome.[21] Recapitulating, the degree of inequality of the reward mechanism should affect equilibrium behavior once we allow for equity considerations, and consequently the initial superiority of the discriminating reward mechanism over the symmetric one should vanish.

3 Experimental Results

In this section, we present the results of our experiment with regard to our research questions. First, we show that workers' behavior is indeed sensitive to the type of production function they face in their joint project, and that the unequal treatment of equals does not necessarily hamper full effort provision. Accordingly, we then present data on a change in the reward scheme from a discriminating to an egalitarian one, which suggests that equal treatment of equals does not necessarily promote full effort provision within a team of agents.

3.1 Sensitivity to the Production Function

Figure 1 shows the mean effort over all periods, conditional on player's reward type, for our three treatments 345COM, 345SUB and 444COM.

Focussing on the discriminating reward scheme, overall effort levels are much higher under a production function of complementarity than under

[21] For the sake of completeness, in 345SUB, their model not only predicts $(0, 1, 1)$ but also $(0, 0, 1)$ as a possible outcome. Calculations are available upon request.

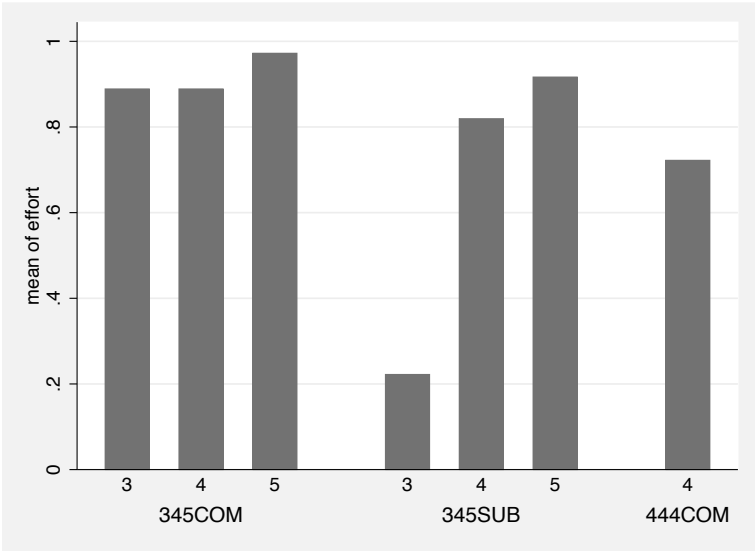

Figure 1: Mean effort per reward type for the three treatments

a production function of substitutability. 91.7% of all effort decisions in 345COM are to work hard, compared to only 65.3% in treatment 345SUB (rank-sum test, $Prob > |z| = .0004$). In 345COM, 6 out of 12 (9/12) groups exert full effort in all periods (all but one period), whereas the same is never observed in 345SUB.

The difference in efficiency between 345COM and 345SUB is predicted to stem from a difference in the behavior of the low-reward type in equilibrium. As can be seen in Figure 1, the average effort level of the low-reward type in the substitution treatment is significantly lower than that of the other two types (22.2% vs. 81.9% and 91.7%, signed-rank test, $Prob > |z| = .0074$ and .0039). It is also significantly lower than the effort level of the same type in the complementarity treatment (22.2% vs. 88.9%, rank-sum test, $Prob > |z| = .0001$). Subjects' individual beliefs are in line with the finding. In 345COM, medium- and high-reward players believe that the low-reward player will work in 85% of all cases, while in 345SUB the low-reward player is expected to work in only 33% of all instances (rank-sum test, medium-reward: $Prob > |z| = .0004$, high-reward: $Prob > |z| = .0007$).

The effort levels of the medium- and high-reward types in 345COM (88.9% and 97.2%) do not differ from the corresponding levels that we observe in

345SUB. Overall, when standard equilibrium predictions dictate effort exertion, the observed effort levels are over 80%. In the one case in which the equilibrium strategy is to shirk, indeed almost 80% of the decisions are to shirk.

Comparing the sums of effort per matching group in the first round and the last round, we find no indication of a significant time trend (signed-rank test: 345COM $Prob > |z| = .65$; 345SUB $Prob > |z| = .31$).[22] The behavior in the first round reveals a similar picture as above. Again, the number of low-reward players choosing to exert effort is much higher in 345COM than in 345SUB (16.7% vs. 75%; Fisher's exact test $p = .012$). For the other two player types the differences across treatments are only marginal and statistically insignificant (medium-reward type: 91.7% vs. 91.7%, $p = 1$; high-reward type: 100% vs. 91.7%, $p = 1$).

Taken together, under a discriminating reward scheme the effort provision is almost maximal when using a complementarity production function; whereas significantly lower effort rates are observed when using a substitution one. We thus conclude from our experimental data:

Result 1: *In line with Winter's model, agents' observed behavior is sensitive to the production technology. Treating equals unequally by using a discriminating reward scheme leads to almost full efficiency under a production function of complementarity – whereas the same reward scheme does not perform well under a production function of substitutability.*

3.2 Sensitivity to the Reward Scheme

Before we turn our attention to the influence of the reward scheme, let us again point out that the discriminating reward scheme leads to almost maximum efficiency under a production function of complementarity, and that even the low-reward players exert effort in this situation. Notice that this is not to say that equity considerations are completely absent in 345COM. For example, the average rate of effort provision over all periods is signifi-

[22] Cp. the corresponding time-series data in Figures 2 and 3 in the appendix.

cantly different between the low- and the high-reward type (88.9% vs. 97.2%, signed-rank test, $Prob > |z| = .0261$).[23] Also the beliefs of medium- and high-reward players about the low-reward player's decision in the first period reveal some influence of equity considerations, because 42% (wrongly) expect him to shirk.[24] But although we observe some small signs of equity considerations in our data, the influence on the final outcome is negligible in view of the high degree of efficiency in 345COM. This finding is surprising in the face of past findings from other experiments exploring the importance of equity concerns – and the following observations from our equitable reward mechanism treatment 444COM gives rise to further surprise.

Given a production function of complementarity and keeping the total cost of the reward mechanism constant, the observed mean efficiency in the first period is lower under the symmetric reward mechanism (78.9%) than under the discriminating one (88.9%), albeit non-significant (rank-sum test, $Prob > |z| = .1552$). Over the course of the experiment, the difference grows larger and significant (average overall efficiency of 72.2% vs. 91.7%, rank-sum test, $Prob > |z| = .0649$; cp. Figure 1). On average, every reward type in the discriminating treatment provides more effort than the players in the symmetric treatment. Only 3 out of 11 groups (4/11) exert full effort in all periods (all but one period), compared to 6 out of 12 (9/12) groups in 345COM. Moreover, the standard deviation of group efficiencies is significantly higher in 444COM than in 345COM (0.233 vs. 0.158, Conover's squared-ranks test, $Prob > |z| = .0143$).[25]

Our result suggests that equal treatment of equals does not necessarily promote full effort provision within a team of agents. A potential reason for the observed difference in efficiency between the symmetric and the

[23]Yet, note that i) this is likely to be caused by a ceiling effect; ii) in 5 out of the 8 instances where the low-reward player shirks, the behavior might also be explained by self-centered preferences (best response given the individual belief); iii) behavior in the first period actually does not differ significantly across types.

[24]However, this vanishes with growing experience. The frequency changes to 85% if we take all periods into account.

[25]Notice that the difference is not an artifact resulting from the high degree of efficiency in 345COM (which puts a bound on the variance), as the group efficiencies in 345SUB, in which the overall efficiency is similar to that in 444COM, show an even lower standard deviation of 0.068 (cp. Figure 5).

discriminating mechanism might be the introduction of the additional 'all-shirk'-equilibrium in treatment 444COM. Even though it is payoff- and risk-dominated by the 'all-work'-equilibrium, the multiplicity of equilibria introduces strategic uncertainty (cp. van Huyck et al. (1990)).[26] Players formulating beliefs are uncertain whether the other players in their group will work or shirk, which is visible in our data: 83% expect both other players to work in 345COM, whereas only 62% do so in 444COM (rank-sum test, $Prob > |z| = .0979$). This translates into low efficiency rates and a high variance of group efficiencies in 444COM, suggesting that strategic considerations shaped by the reward mechanism are crucial, and outweigh possible equity preferences of the subjects.[27] The asymmetry of the reward mechanism facilitates coordination among the agents. Under the discriminating reward scheme, subjects can anticipate that the high-reward player will exert effort, which in turn incentivizes the medium- and low-reward players to do so as well. On the other hand, the identical rewards under the symmetric mechanism make it hard for the subjects to form beliefs about the action of the other players, so that they are all in the dark. We thus conclude from our experimental data:

Result 2: *Treating equals equally is neither a necessary nor a sufficient prerequisite for eliciting high performance in teams. Asymmetry facilitates coordination under a production function of complementarity, i.e. we observe higher efficiency rates under a discriminating reward mechanism than under a cost-equivalent symmetric one – which is again in line with Winter's model.*

[26]Note that strategic uncertainty should also be present in 345COM (cp. Section 2.2), because 'all-work' *and* 'all-shirk' are potential equilibria once we allow for equity considerations. Yet, we observe almost full efficiency in this treatment.

[27]One might consider that the result may be driven by a difference in the subject population between treatments. However, pairwise comparisons of the corresponding results of the social value orientation test reveals no significant differences across treatments (345COM vs. 345SUB $p = .66$; 345COM vs. 444COM $p = .52$; 444COM vs. 345SUB $p = .98$); in all treatments, subjects' 'value orientations' indicate a general preference for equitable treatment, i.e. they do differ significantly from being strictly self-centered (345COM: $p \leq .001$; 345SUB: $p \leq .001$; 444SUB: $p \leq .001$).

4 Conclusion

In this paper, we studied the interaction in teams. More specifically, we experimentally explored whether workers' behavior is sensitive to the externalities given by the production technology, and whether a major incentive advantage exists when discriminating among perfectly identical agents. In our experiment, three workers simultaneously decide on their individual provision of costly effort to a joint project. Treatments differ in the shape of the project's production technology and of the reward mechanism. Under a production technology of complementarity, the use of a symmetric reward mechanism elicits substantially lower efforts and efficiency than a cost-equivalent discriminating reward mechanism. The same discriminating reward mechanism underperforms when it is utilized under a production function of substitutability.

Our findings have important implications for the design of organizations in practice. First, they clearly point to the relevance of the production function for organization construction – a factor which has so far received little attention in the literature. Designing (production) tasks in a way that makes workers' efforts complements rather than substitutes may lead to a major cost advantage. Insofar as peer pressure constitutes a complementarity in effort exertion, the strengthening of social ties amongst the workforce alone might have a strong impact on productivity.

Second, and closely related, is our finding that unequal treatment of equals does not necessarily hamper efficiency. Whenever the organizational technology is one of complementarity, i.e. whenever the impact of a worker's input increases in the size of the others' input, the usage of a discriminating reward scheme might be potentially efficiency-enhancing. The main reason for this is that asymmetric rewards facilitate coordination, because workers can anticipate that those who have high stakes at hand will certainly exert effort – which in turn incentivizes the other workers to exert effort as well. Consider that discrimination must not necessarily be in monetary terms, but might also take the form of hierarchies. While a vast body of literature in personnel economics already promotes the implementation of hierarchies

(e.g. Lazear and Rosen (1981)), our results suggest that hierarchies might enhance performance despite the absence of the existing literature's usual assumptions of monitoring or authority relations.

In this regard, we more generally contribute to the ongoing research on behavioral phenomena in organizations. As James Konow (2000) puts it: *"Many of the successes of economics can probably be attributed to its pushing the assumption of self-interest to the extreme. To proceed further, however, it may be necessary to incorporate richer behavioral assumptions that include fairness and other moral standards."* [28] While we agree in principle, it should be added that it is additionally necessary to identify the situations in which behavior is in line with the classical model – which is ultimately an empirical question. Only then can we really understand how to model the richer behavioral assumptions in a way to advance Economics.

The results in this paper should not be taken as arguments against the importance of equity considerations in general. They rather suggest that equal treatment of equals is neither a necessary nor a sufficient prerequisite for eliciting high performance in teams.[29] Yet the relative importance of equity considerations is likely to depend on the exact details of the organizational setting and framework. In this paper, we presented experimental evidence for some of these settings, and stressed the interaction between production technologies and reward mechanisms. Other interesting variations of the organizational settings include a change in the timing of effort choices, the introduction of heterogeneity among the workforce or the use of 'symbolic'

[28] Konow (2000), p. 1089.

[29] Taking a theoretical viewpoint, one might argue that this result is not surprising since it immediately arises from Winter's model. However, theoretical results need not necessarily be compatible with actual behavior. This is nicely captured by the following quote from Falkinger et al. (2000, p. 248) in the context of public goods provision mechanisms: *"[The theoretical] mechanisms are desirably simple and do well in theory. It is, however, important to note that the fact that a mechanism does well in theory, does not tell us much about its effectiveness in the laboratory and in practice. In principle, it could well be the case that although the Nash equilibrium in the presence of the mechanism implies an efficient provision of the public good, subjects' actual behavior will generate significant under- or overprovision. .. Deviations of actual behavior from the equilibrium predicted by theory .. can arise because subjects' motivations differ from the theoretically assumed preferences."* Subject to these considerations, our empirical findings become all the more important.

instead of monetary differentiation. Extending our simple design allows for studying these and other interesting aspects in the future.

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Appendix A: Instructions

This is the English translation of the instructions used in treatments 345COM and 444COM. In treatment 345SUB, the table and examples were adjusted to fit the production function.

Welcome to this decision-making experiment. Please read the following instructions carefully. The experiment will be conducted anonymously, that is to say you will not learn with whom of the other participants you are interacting. Please keep in mind that from now on and throughout the experiment you are **not allowed to talk to the other participants**. If you **have any questions**, please give a signal with your hand and we will come to you. During the experiment you can earn Taler. How much you earn depends on your decisions and the decisions of the other participants in your group. At the end of the experiment these Taler will be converted to Euro at an exchange rate of **80 Taler = 1 EURO**. The Euro amount will be paid out to you. You will be called to collect your earnings. Please turn in all instruction sheets when you collect your earnings.

In this experiment you will be randomly divided into groups of three persons. Together with two other participants you form a group. Each participant decides whether he wants to **work normal or hard**. The more participants choose to work hard, the more units of goods will be produced.

Number (#) of hard working participants	0	1	2	3
Produced units of goods	20	40	65	100

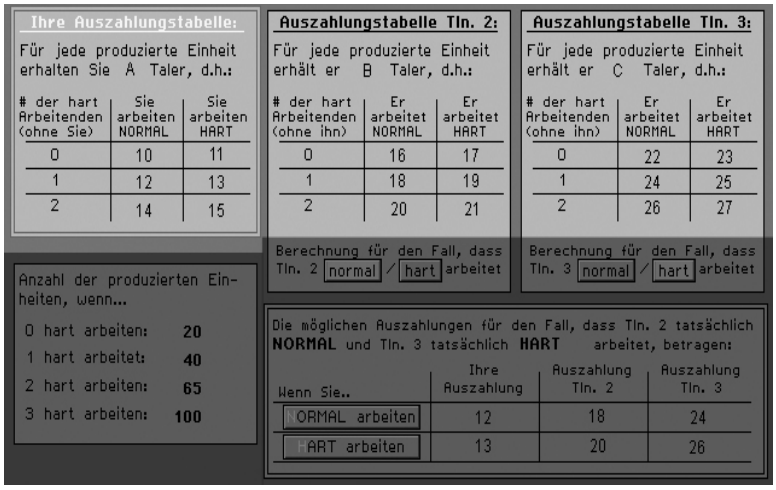
Examples: In case that all participants of the group work normal, 20 units will be produced altogether in your group. If you work hard and another participant in your group works hard as well, 65 units will be produced altogether in your group. etc... good

For each unit of goods produced, you receive a certain amount of Taler. At the beginning of the experiment you are informed how many Taler you earn per unit produced. Additionally, you learn how many Taler per unit the other two participants in your group earn. Examples: In the beginning of the experiment you are told that you receive 5 Taler for each unit produced. In

case that all participants in your group work hard, 100 units will be produced and you receive 500 Taler. In case that 40 units are produced, you receive $40 \cdot 5 = 200$ Taler. etc...

Costs: If you decide to **work hard**, the amount you receive is reduced by 90 Taler. If you **work normal**, no additional costs arise. Examples: You and another participant in your group work hard, so 65 units are produced. Accordingly, you receive $65 \cdot 5 = 325$ Taler. Since you worked hard, 90 Taler are taken away. Hence, your final payment is $325 - 90 = 235$ Taler. If instead you worked normal, 40 units would be produced. You would receive $40 \cdot 5 = 200$ Taler. Since you worked normal, no Taler are subtracted from this amount. Hence, your final payment would be 200 Taler. etc...

In order to facilitate the decision-making process, each participant is informed in detail about his own possible payoffs and the payoffs of the other two participants in his group. The corresponding information is given in table form. For every participant, a table lists all possible payments dependent on the own decision (to work normal or hard) and the decisions of the other two participants in the group (none, one or both work hard). In these tables, the corresponding costs for working hard have already been subtracted. Below, you see an example with fictional data:



Ihre Auszahlungstabelle:

Für jede produzierte Einheit erhalten Sie A Taler, d.h.:

# der hart Arbeitenden (ohne Sie)	Sie arbeiten NORMAL	Sie arbeiten HART
0	10	11
1	12	13
2	14	15

Auszahlungstabelle Tln. 2:

Für jede produzierte Einheit erhält er B Taler, d.h.:

# der hart Arbeitenden (ohne ihn)	Er arbeitet NORMAL	Er arbeitet HART
0	16	17
1	18	19
2	20	21

Berechnung für den Fall, dass Tln. 2 normal / hart arbeitet

Auszahlungstabelle Tln. 3:

Für jede produzierte Einheit erhält er C Taler, d.h.:

# der hart Arbeitenden (ohne ihn)	Er arbeitet NORMAL	Er arbeitet HART
0	22	23
1	24	25
2	26	27

Berechnung für den Fall, dass Tln. 3 normal / hart arbeitet

Anzahl der produzierten Einheiten, wenn...

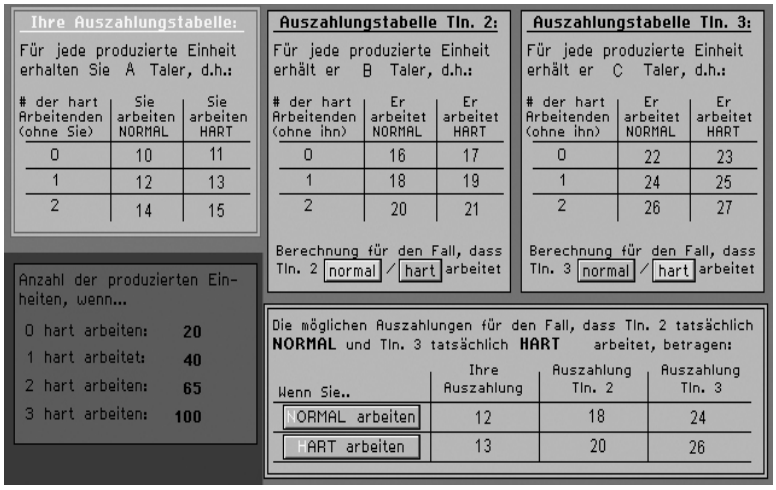
0 hart arbeiten:	20
1 hart arbeitet:	40
2 hart arbeiten:	65
3 hart arbeiten:	100

Die möglichen Auszahlungen für den Fall, dass Tln. 2 tatsächlich **NORMAL** und Tln. 3 tatsächlich **HART** arbeitet, betragen:

Wenn Sie..	Ihre Auszahlung	Auszahlung Tln. 2	Auszahlung Tln. 3
NORMAL arbeiten	12	18	24
HART arbeiten	13	20	26

In the lower right part of the screen, you can see another table. At the beginning, the table is empty. In order to display data, you first have to create a hypothetical situation: In the table of participant number 2, click

on the corresponding button what you think how he will decide (to work normal or hard). Furthermore, in the table of participant number 3, click on the corresponding button what you think about his decision (to work normal or hard). In the lower table you will then be shown in the first row what the payment for you and the other two participants would be, in case that your chosen situation actually occurs - and that you decide to work normal. The second row lists the possible payments that you and the other two participants would receive, in case that your chosen situation actually occurs - and that you decide to work hard. At any time, you can display data for a different situation. Simply change the situation by clicking on a different button underneath the payment tables of participant number 2 and 3. Below you see another example with fictional data:



Ihre Auszahlungstabelle:

Für jede produzierte Einheit erhalten Sie A Taler, d.h.:

# der hart Arbeitenden (ohne Sie)	Sie arbeiten NORMAL	Sie arbeiten HART
0	10	11
1	12	13
2	14	15

Auszahlungstabelle Tln. 2:

Für jede produzierte Einheit erhält er B Taler, d.h.:

# der hart Arbeitenden (ohne ihn)	Er arbeitet NORMAL	Er arbeitet HART
0	16	17
1	18	19
2	20	21

Berechnung für den Fall, dass Tln. 2 normal / hart arbeitet

Auszahlungstabelle Tln. 3:

Für jede produzierte Einheit erhält er C Taler, d.h.:

# der hart Arbeitenden (ohne ihn)	Er arbeitet NORMAL	Er arbeitet HART
0	22	23
1	24	25
2	26	27

Berechnung für den Fall, dass Tln. 3 normal / hart arbeitet

Anzahl der produzierten Einheiten, wenn...

0 hart arbeiten:	20
1 hart arbeitet:	40
2 hart arbeiten:	65
3 hart arbeiten:	100

Die möglichen Auszahlungen für den Fall, dass Tln. 2 tatsächlich **NORMAL** und Tln. 3 tatsächlich **HART** arbeitet, betragen:

Wenn Sie..	Ihre Auszahlung	Auszahlung Tln. 2	Auszahlung Tln. 3
NORMAL arbeiten	12	18	24
HART arbeiten	13	20	26

Your decision: As soon as you have decided on whether you want to work hard or normal, please click on the according button in the lower right table (on the left hand side). The program will ask you to confirm your decision. Afterwards, your decision will be transferred. Please remain in your cubicle and wait until all participants have reached a decision. Afterwards, you will be informed about the number of units produced in your group and about your payoff. This amount will be paid to you in cash and anonymously at an exchange rate of 80 Taler = 1 EURO.

If you have any questions please give a signal with your hand!

Appendix B: Supplementary Data

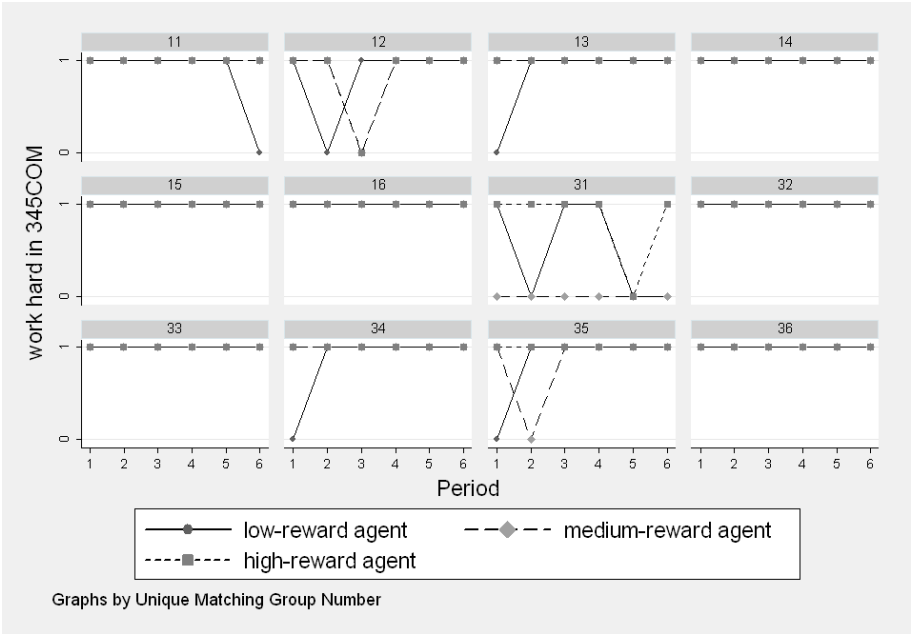


Figure 2: Effort per reward type over time in 345COM

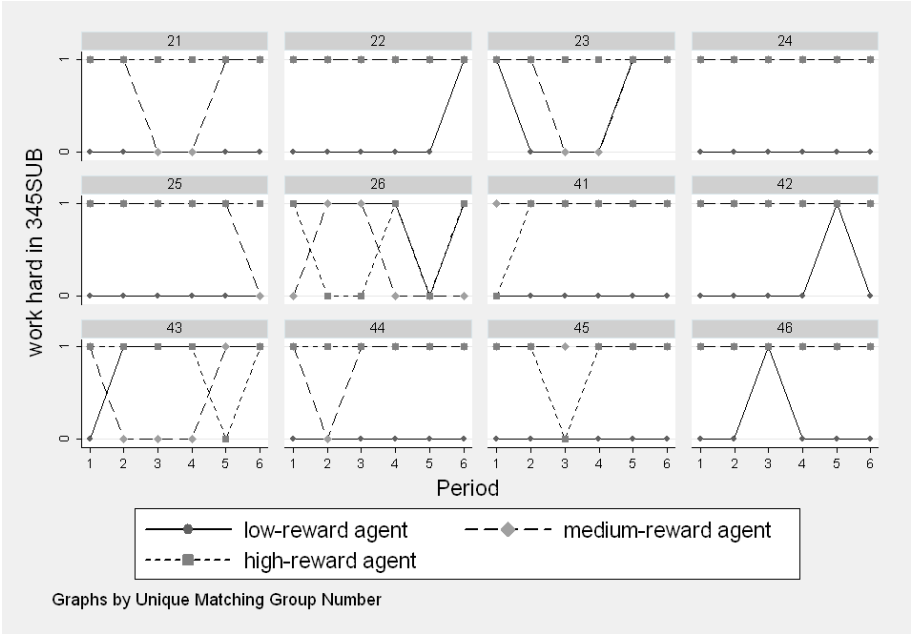


Figure 3: Effort per reward type over time in 345SUB

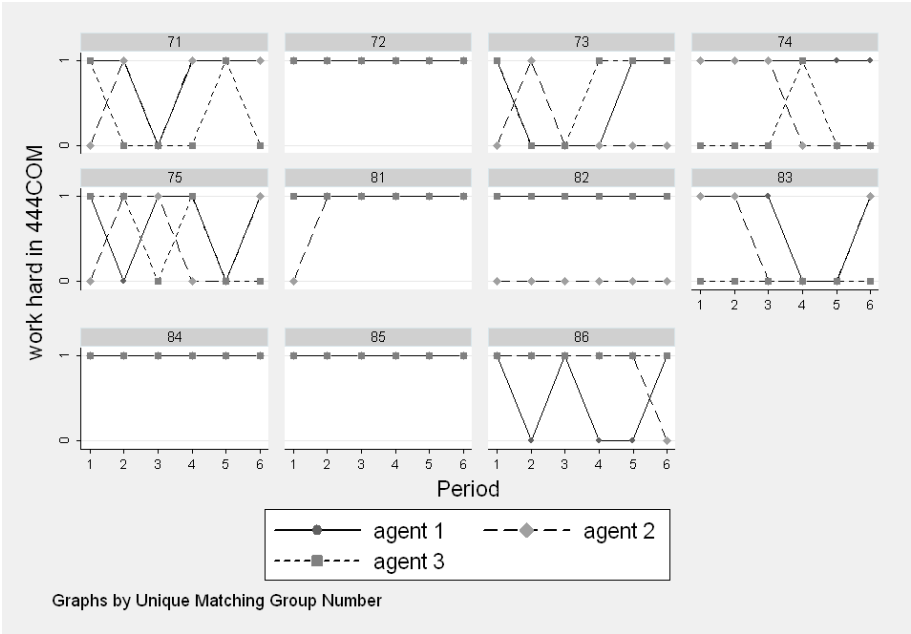


Figure 4: Effort per agent over time in 444COM

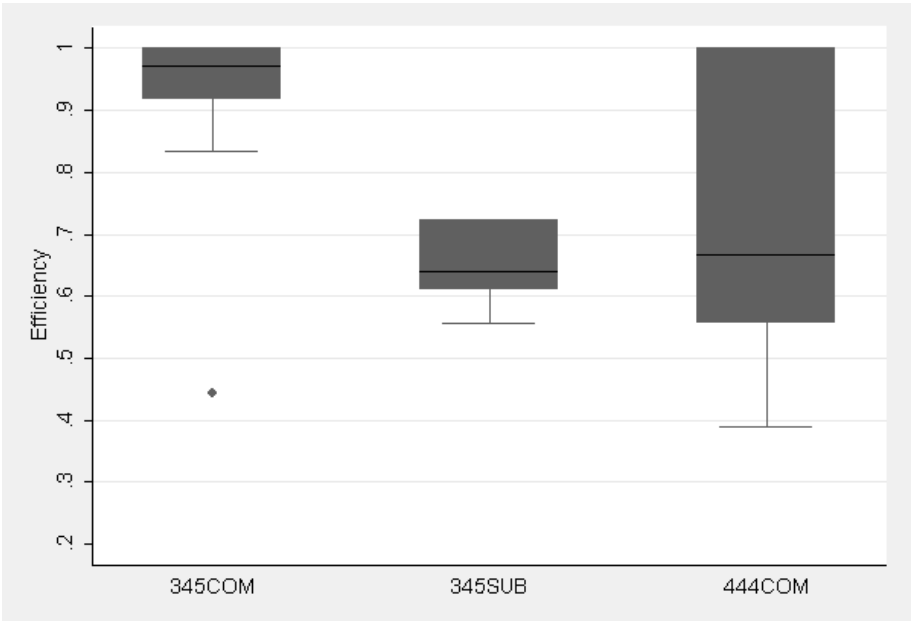


Figure 5: Boxplots of average group efficiency rates