The impact of heterogeneity in endowments and norms on common good provision

Thomas Falk, Dirk Lohmann, Nadege Azebaze

Abstract

Achieving cooperation in natural resource management is always a challenge when incentives exist for an individual to maximise her short term benefits at the cost of a group. We assess the situation of a social dilemma in water supply cooperation within land reform projects in Namibia. In the context of the Namibian land reform, beneficiaries share the operation and maintenance of water infrastructure in order to gain economies of scale. Our paper assesses how alternative fairness norms affect the probability of cooperation.

In the first step of our research we conducted an exploratory overview of the social-ecological system of central Namibian land reform projects. The SES-framework of Ostrom (2009) served as a guideline for this assessment. Taking into account the complexity of the cooperation situation we designed a role-play which is based on a social-ecological simulation model. The experiment simulates the real life decision situation of land reform beneficiaries where equilibriums are permanently changing. This approach helped us not only to better understand the cooperation challenges of Namibian land reform beneficiaries but provided support to stakeholders in their decision making and institution building.

Our study provides evidence that different fairness norms overlap. Land reform beneficiaries increase their contributions as the other group members increase their payments (conditional cooperation), as they are more productive (inequality aversion) and own more livestock (congruence of appropriation and provision & inequality aversion). Decisions are made considering the overall context. We further see evidence that norm homogeneity is in particular critical fort he success of collective action if there is a high degree of endowment heterogeneity.

Key words: collective action, group heterogeneity, land reform, participatory ecological-economic modelling, Namibia

1 Introduction

Achieving cooperation in natural resource management is always a challenge when incentives exist for an individual to maximise her short term benefits at the cost of a group. Since everybody in the group has the same rationality, the group would be trapped in a situation in which it misses out on potential gains. The Prisoners dilemma or Hardin's Tragedy of the Commons (Hardin 1994) are illustrations of this problem (Bardhan 1993). From a more natural scientist point of view, Nowak (2006) argues that defectors in a group of cooperators have a higher average fitness than cooperators who vanish from the system as a result of selection. Populations consisting only of cooperators, however, have a higher average fitness.

Observations both of natural and social systems demonstrated that it is possible to achieve cooperation (Nowak 2006, Ostrom 1998, 2010). Therefore, the focus of attention shifted towards the assessment of factors increasing or decreasing the probability of cooperation.

One such factor receiving attention in recent years is the heterogeneity of cooperating groups. There is a popular logic that social, cultural, and economic homogeneity of cooperating groups increases the predictability of interactions and therefore supports collective action (Poteete and Ostrom 2004, Ruttan 2008). Baland & Platteau (1996) distinguish three sources of heterogeneity:

1) ethnic, race or other cultural divisions;
2) variations in endowments;
3) differences in interests.

Cultural differences can result in different interpretations of rules (Baland & Platteau 1996). It might impede the development of trust (Poteete & Ostrom 2004) and potentially increases the transaction costs of monitoring and enforcement as social and moral consequences for complying with institutions may be less effective (Rustagi et al. 2010, Falk et al. 2012).

Inequality of wealth interacts with the relative costs and benefits of cooperation (Poteete & Ostrom 2004). Due to differences in endowments diverse user groups may have different opportunity costs related to the resource use. Both cases can hamper cooperation but can be solved by adapted appropriation and provision institutions. Oppositional, Olson (1995) argues that in cases when the rich receive disproportional high benefits from the resource they are willing to make disproportional provisions (Baland & Platteau 1996). This requires, however, low emotional costs of subsidising free-riding of the poor.

Heterogeneity of interests may affect incentives to cooperate if for instance the dependency on the resource varies and consequently discount rates are not the same. Less dependent users may try to exploit short term benefits which can lead to a collapse of collective action. The empirical evidence on the role of group heterogeneity is, however, ambivalent (see e.g. Baland & Platteau 1996, Varghuese & Ostrom 2001, Ruttan 2008) and a more thorough assessment of it's impact on the success of cooperation is needed. Varghuese & Ostrom (2001) argue that groups can overcome challenges related to heterogeneity by crafting appropriate institutions. They claim that if benefits are substantial, users are likely to invest in effective rules which are perceived to be fair (see also Buckley & Croson 2006). What happens, however, if the perceptions on fairness differ within the group (Ostrom 1998)? In this paper we will look at the impact of heterogeneity on the provision of a collective good in general and the interactions between types of heterogeneity in particular.

We study the case of water supply cooperation within land reform projects in Namibia. In the context of the Namibian land reform, beneficiaries share the operation and maintenance of water infrastructure in order to gain economies of scale. Even though there are small groups with direct communication possibilities, it is not uncommon that groups cannot come to an agreement in time such that water points are not maintained causing additional costs. Taking a broad summary of the socio-ecological system as a starting point, we will assess whether we can observe signs of alternative fairness norms in role-play exercises. Specifically we look for a) norms of the congruence of appropriation and provision (Ostrom 1998, 2010, design principle 2B) and b) norms of inequality aversion (Fehr & Schmidt 1999) in the sense of conditional cooperation (Fischbacher & Gächter 2010). This distinction is relevant as individual payments under the two norms differ depending on the endowments of group members.

In summary, we want to answer the following questions:

Which fairness norms dominate in our sample? Is fairness understood as congruence of appropriation and provision or as inequity aversion/conditional cooperation?

Has the interaction between norm heterogeneity and heterogeneity of endowments have an impact on the success or failure of collective action?

In following section we will give an explorative overview of our case study based on the Social-Ecological-System Framework of Ostrom (2009). We will than describe in Section 3 how we translated this situation in simulation-model-based role plays. Section 4 summarizes our theoretical deliberations before we present the empirical results of the role plays in Section 5. We draw our conclusions in Section6.

2 Explorative description of the social-ecological systems of land reform projects in central Namibia

Cooperation patterns of land reform beneficiaries are the outcome of complex features of social-ecological systems (SES). We structure our explorative assessment according to the SES framework of Ostrom (2009) into four main sub-systems: a) users as actors, b) governance system, c) resource system, and d) resource units.

2.1 Governance System (GS)

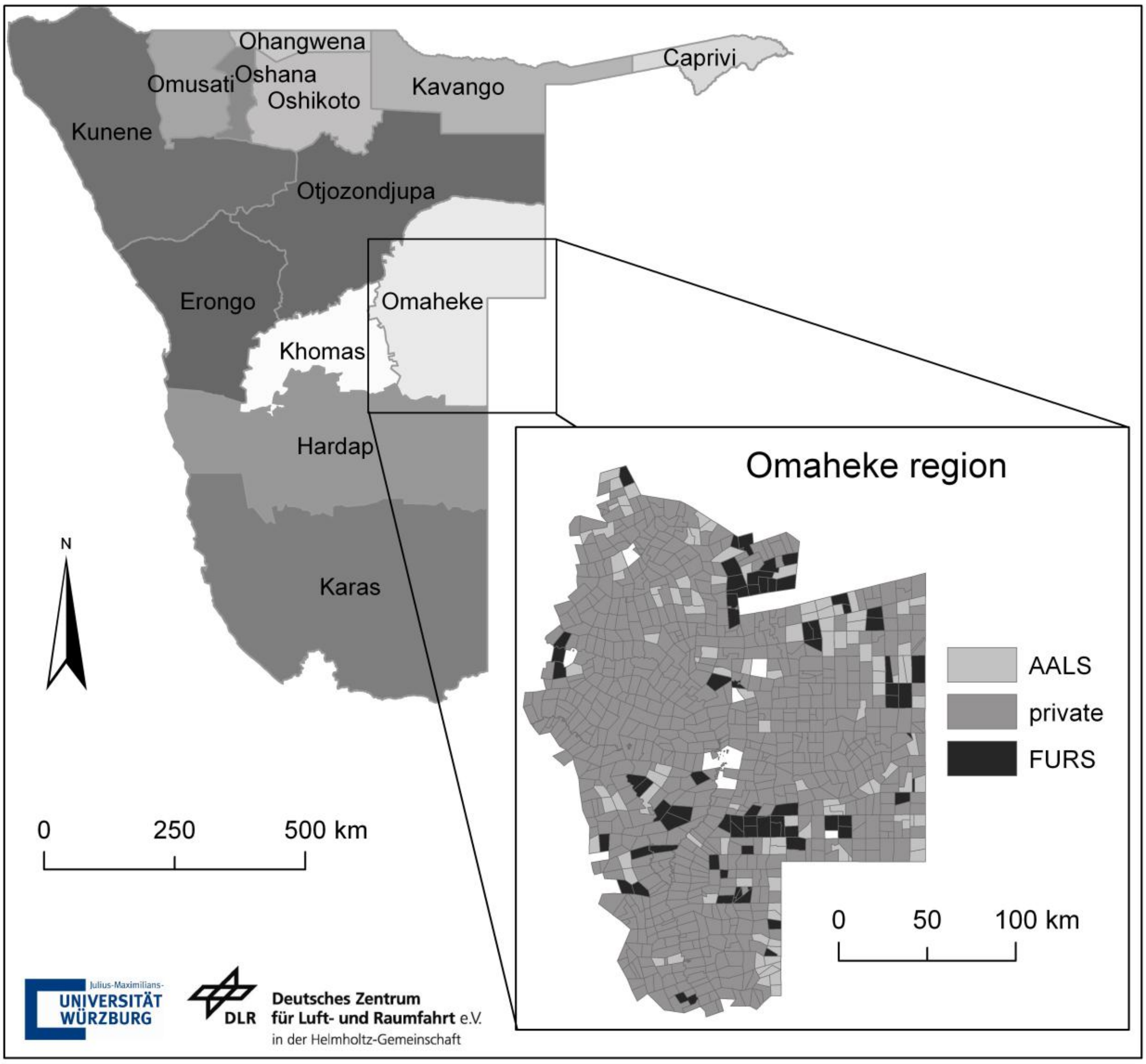
Land Reform is an important project of independent Namibia as it not only cures an unfair land distribution but also maintains political stability in the country. For more than 18 years, land has been redistributed to previously disadvantaged groups of the Namibian society using a broad range of instruments, such as group resettlement, subsidized loans, redistribution of government land and in a few cases also expropriation. In this paper we focus our attention on the *Farm Unit Resettlement Scheme* (FURS) which is based on the willing-seller willing-buyer principle. The acquisition is based on the preferential right of the Namibian state to purchase agricultural land whenever any owner of such land intends to dispose of it (RoN 1995a). The government divides the farms into smaller portions and any Namibian citizen who has been socially, economically or educationally disadvantaged by past discriminatory laws can apply for an allotment of land acquired for resettlement (e.g. RoN 2002). Successful applicants are supposed to receive a 99-year lease agreement with the government. In contrast to this we observe that by 2008 exactly half of the FURS farmers in our sample did not receive a leasing contract from the Ministry of Lands and Resettlement which administers FURS. These beneficiaries therefore hold no written proof of their rights on the allotted land (Falk et al. 2010, Werner & Odendaal 2010). On reason for the delay in issuing the contracts is the obligation of the government to fully maintain and repair the water infrastructure on the farm before redistribution. The responsible units lack, however, the capacity to cover all farms in time. Insecure property rights to their farm units decrease incentives to maintain infrastructure (Deiniger & Feder 2009).

FURS farmers can benefit from cooperation with neighbouring farmers especially because they tend to use relatively small farm units and can accomplish economies of scale. The beneficiaries, however, face the challenge that they have to establish totally new collective choice and operational rules and need to agree on a monitoring and enforcement system. The farmers did not know each other before resettlement and often come from different ethnic groups with different value sets.

2.1.1 Resource System (RS) and Resource Units (RU)

The research was conducted in the Omaheke region in east central Namibia (Figure 1). Our research concentrated on the eastern part of the region where the vegetation is dominated by an *Acacia-Terminalia* tree-and-shrub savannah of the Central Kalahari (Mendelsohn 2002). With an annual average rainfall between 300 mm – 400 mm, the region is considered to be a high potential livestock farming area. The carrying capacity is estimated to be between 12 and 18 ha/LSU (Mendelsohn, 2006).

Figure 1: Map of Namibia and research region, *Source: Mendelsohn 2002*



All land reform beneficiaries in our sample are active in the agricultural sector of livestock farming mainly with cattle. FURS farmers are allotted individual clearly marked sections of land. The size of the farms, however, varies widely between 50 ha and 2.000 ha within our sample. Concerns have been expressed repeatedly that government allotments are too small to accomplish economies of scale and thus economically unviable land units (Werner & Odendaal 2010). This problem can be partly solved by establishing cooperation and collective action (GS6) between users of small farms as is common with regard to the management of water infrastructure. Typically, water infrastructure was prior to resettlement managed centrally by one decision unit. With splitting up the farms often not each unit has exclusive access to a pump. As a consequence, the occupants of farm units are forced to cooperate in the provision of infrastructure maintenance and appropriation of water. A lack or breakdown of water infrastructure restricts the opportunities to make full use of the land, causes costs of livestock losses, or requires making use of more costly water supply options. In addition, a high concentration of livestock around few water points potentially causes localised degradation. On the farms in our sample, one working pump had to serve between 50 and 2000 ha (mean = 1369 ha).

2.1.2 Land users as actors (A)

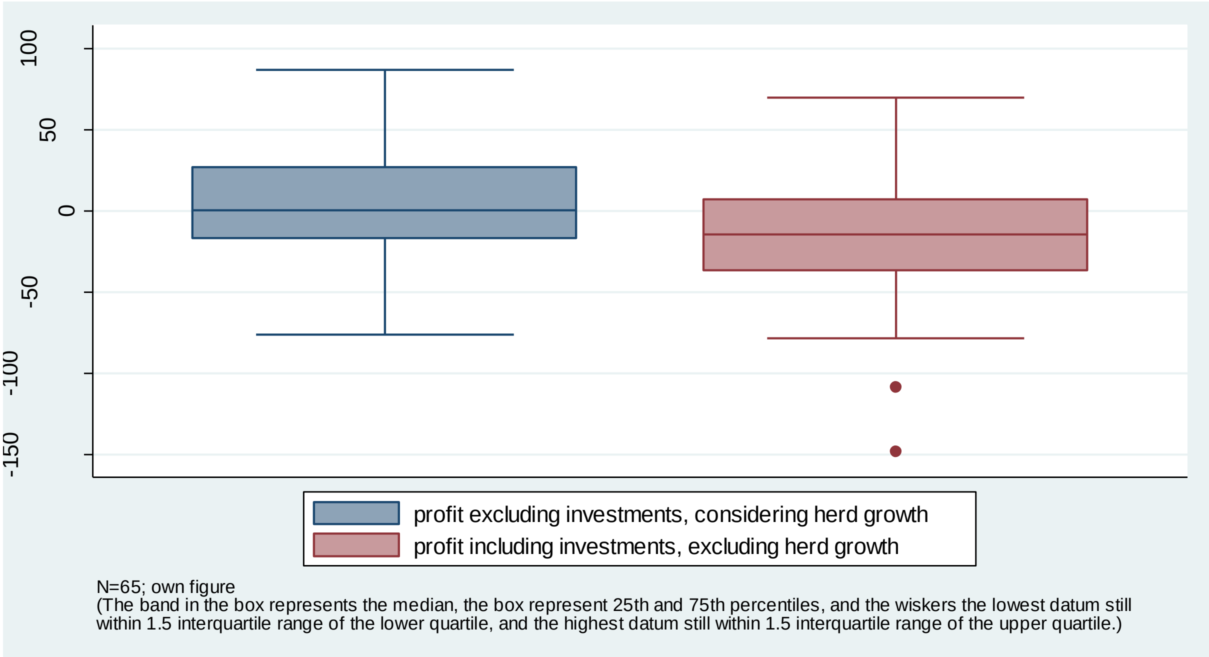
Our sample consists of individual farmers using one farm unit exclusively. The government's selection criteria for FURS beneficiaries have repeatedly changed but the program generally focuses on the poor. 60 percent of the household heads of the sample are full-time farmers.[i] The remaining part-time farmers spend on average 75 days per year on the farm. 80 percent of the respondents claimed to have non-farm income. 44 percent of the household heads did not finish secondary school, 47 percent finished secondary school as the highest degree, and 9 percent hold a technical or university degree. 72 percent of our sample had previous farming experience but only a minority of them in a commercial setting. Only 23 percent of the respondents received some kind of farming training.

The median of the size of the groups sharing water infrastructure was 2.5 (min=2, max=6). In 43 percent of the groups more than one ethnic group was represented (maximum = 3).

The average annual gross profit of our respondents adding up all on-farm income, deducting only running costs and adding the average annual herd growth was N$ 5,463 with a high standard deviation of σ = 32,466. Almost half of our sample was making losses under this most optimistic income calculation. The figures for the net farm profit, which include fixed costs, 2008 investment costs, and liability payments but exclude herd growth are even worse.

The net farm loss was on average N$ 14,395 (σ = 37,708). According to this indicator almost two third of the sample was making losses (Figure 2, Falk et al. 2010).

Figure 2: Farm profit calculations considering herd growth and investments



3 Role-plays based on ecological-economic modelling simulating complex decision making situations

The application of the SES-framework made us aware of the complexity of the challenge to collectively maintain water infrastructure on Namibian land reform farms. Namibian land reform beneficiaries operate in systems of dynamic complexity. Amongst others these are marked by permanent and often delayed changes, multiple feedbacks at different speeds, nonlinear relationships of variables, and often irreversible developments (Sterman 2001, 2006, Barreteau et al. 2001). The systems are reflexive, acting on decision makers, who through their actions act on various components of the system (Bousquet et al. 2002). We represent a situation where the absolute and relative endowments of land reform beneficiaries are permanently changing, resulting in erratically changing equilibriums. As a consequence the farmers are confronted with the permanent need to review institutions taking internalised fairness norms into account. Since the social-ecological system we are dealing with has a considerable complexity we decided to use a computer simulation to represent it (see also Sterman 2001).

Following the general approach of Bousquet et al. (2002) we applied role plays in order to acquire knowledge, build a model, validate the model, and support decision making processes. Our model and its conversion into a role play simulate the complexity and dynamics of important parts of the social-ecological system and provide support for negotiation (see also Barreteau et al. 2001). Our model created a virtual world in which farmers could experiment, rehearse decision making, and play in a compressed time and space (see also Barreteau et al. 2001, Sterman 2001, 2006). The model provided them with immediate feedback and allowed them to adjust decisions. Experimenting with the simulation model induces much lower costs and risks for the players than a real life trail and error process of institutional change (Barreteau et al. 2001, Sterman 2006).

Compared to standard experiments this approach has a number of obvious disadvantages. The internal validity is low as it is difficult control parameters. As a consequence the results are difficult to compare (Bousquet et al. 2002). The role plays are not suitable to test general theoretical hypothesis. Generating accepted scientific evidence requires controlled experiments which discriminate hypotheses and produce replicable results (Sterman 2006). The more complex the phenomenon, the more difficult it is, however, to draw conclusions from standard experiments on real life decision situations.

The advantage the simulation model based role plays is a higher external validity and a more realistic reproduction of real life decision situations (Barreteau et al. 2001). The objective of the role games is to assess in a less controlled way a representation of reality rather than studying a theoretical pre-given one (Bousquet et al. 2002).

As a starting point we used an existing vegetation model (Tietjen et al., 2010) and parameterised it for the Omaheke region/Namibia based on empirical field work, expert knowledge and a literature review. The model simulates the dynamics of natural resources depending on environmental conditions (precipitation/climate, hydrology, ecological interactions) and land use impacts. This ecological model was then dynamically linked to an economic model that allows for the inclusion of livestock related decisions of farmers as well as cooperation in water management. For a more detailed model description please see Appendix 1.

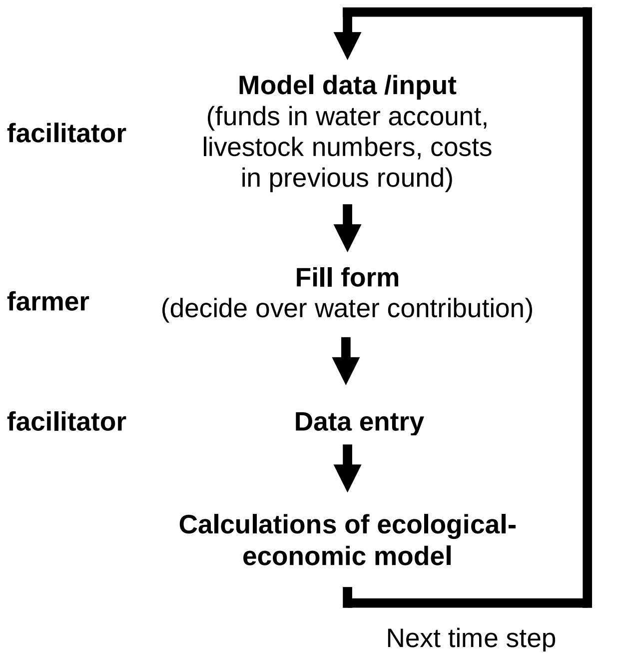
The ecological-economic model was than converted into a computer based role play representing the provision situation of a common good. The plays simulate basic farming decisions and the voluntary contribution to water provision. We designed a user interface that allows the communication between the facilitator and the model. The interface presents a model output of all important state variables and allows for a subsequent input of the farmers' decisions (e.g. amount of money to be paid to a water fund). Based on illustratively communicated ecological and economic information calculated by the model, farmers make decisions regarding their stocking rates as well as their individual contribution to the maintenance of water infrastructure. The decisions on stocking rates are relevant for our assessment of cooperation patterns because the livestock numbers change opportunity costs of infrastructure maintenance.

Outputs on the vegetation state are given using photographs taken from different vegetation states in the research region. The same approach of showing pictures is used for showing the body score of the livestock. Printout outputs are generated for every time step to present all other relevant numbers. Farmers receive a list in their mother tongue with the following information:

- rainfall in the previous experiment period,
- number of livestock at the beginning of experiment period,
- age structure of livestock at the beginning of experiment period,
- number of livestock losses in the previous experiment period,
- individual farmer’s account balance at the beginning of experiment period,
- total farms expenses to be covered in experiment period,
- account balance of the group’s water fund at the beginning of experiment period.

In every time step the farmers can make two kinds of decisions: 1) they can buy or sell livestock, and 2) they have to decide how much to pay into their group’s water fund. The game is set up in a way that all players have the opportunity to continuously communicate face to face as this is the most efficient form of communication for developing institutions (Balliet 2011) and a realistic representation of the real-life situation.[ii] Depending on the players’ decisions, new ecological and economic states (e.g. condition of livestock, account balance) are calculated, again as the basis for the next steps’ decisions. Figure 3 illustrates the experiment process.

Figure 3: The cyclic process of our computerized experiment



The modelled water infrastructure costs vary from year to year, reflecting randomly appearing maintenance costs. In the experiment, each group shares water infrastructure which consists of a diesel driven and a wind driven pump. The costs are modeled on the basis of expert interviews and on average set at N$ 2350 ($\sigma = 785$) for the diesel driven pump and N$ 750 ($\sigma = 250$) for the wind driven pump. Farmers are not informed about the periods' water costs before making their contribution and therefore have to make decisions under uncertainty.

In the case that the money available in the fund is insufficient to cover the maintenance costs, the infrastructure breaks down. In reality the farmers usually take their cattle to the neighbouring farm where they have to pay, however, for getting access to water. We assume a hypothetical fee of N$ 50 per head of cattle which is based on interviews with farmers even though the amount strongly varies in reality.

Between January and April 2009 we conducted game sessions with 45 land reform beneficiaries on 14 resettlement farms. In an attempt to simulate the real life cooperation situation, the experiments where played in groups of farmers who in fact share a water point. Players where given a virtual farm of the same size as their real life one and started with virtual livestock numbers being equal to their real livestock numbers in 2008.

For the data analyses, we identified groups agreeing to a rule by the standard deviation of their payments. If the group's standard deviation of the water payments was zero in an experiment period, we concluded that the group was following the rule to pay equally per person representing the norm of conditional cooperation. If the group's standard deviation of the water payments divided by livestock numbers was zero in an experiment period, we concluded that the group was following the rule to pay per head of livestock representing the norm of congruence of appropriation and provision. Descriptive statistics and correlation analysis where used for basic analyses.

In addition, the experiment data were analyzed calculating Random Effects regression models. These methods are applied to panel data sets where each research period of each player is analyzed considering dependencies between the behaviours of one player in different experiment periods. The empirical model explains for each year the individual's contribution to the maintenance of water infrastructure depending on the input variables in the experiment and group characteristics.

4 The Theory

In the following section expected outcomes of the experiment are described theoretically. The model aims at drawing basic conclusions regarding the individual contribution and free ride incentives of the farmers. In contrast to the experiment this model will only analyze the decision on the amount the farmers want to pay into the water fund. The decision to sell or buy livestock is not part of this analysis. Other costs like production costs, transactions costs, etc. are neglected.

Consider a group of 2 farmers. Each farmer has to contribute an amount C_i, $(i \in \{1, 2\})$, into the water fund to cover the maintenance costs. In the experiment the farmers play over 10 round. The relation between the current and the following game round is the amount remaining in the fund after subtracting the maintenance costs. There is no time preference and interest rate. After the farmers have paid their contribution into the water fund, its value is given with:

$WF_t = C_1 + C_2 + WF_{t-1}$

The basic condition for the use of the water infrastructure by a farmer or a group is the fulfillment of the individual or the group participation incentive.

$OC_i > C_i \quad \text{or} \quad OC_N > C_N$

At the group level, the total opportunity costs (OC_N) of both farmers must be higher than their total contribution (C_N). At the individual level the opportunity costs of a farmer (OC_i) must be higher than his contribution into the water fund (C_i).

The maintenance costs (K) are uncertain. The costs are continuously equally distributed in the interval [0, V], with V being the value of building a totally new water infrastructure. If the amount in the water fund (WF) does not cover the maintenance costs, the infrastructure breaks down and the group faces the opportunity costs of N$ 50 per head of livestock. The survival of the water infrastructure depends on the probability that the amount in the water fund is higher that the maintenance costs: $P(K \leq WF) = F(WF)$.

Each farmer acts to minimize his expected costs:

$$EC_1 = C_1 \cdot F(WF) + (1 - F(WF)) \cdot OC_1 \qquad (1)$$

Once a water point has been allocated to a group of farmer, they cannot exclude a group member from its use. They can, however, exclude external intruders. Public good experiments representing the provision challenge have shown that people cooperate much more than predicted by some standard economic models considering the individuals as being selfish. A possible explanation of this behavior is that some individuals are conditional cooperative as a result of inequity averse preferences (Fischbacher et al. 2001). In this case a player experiences some disutility, if his contribution is different to the contribution of the other farmer. This intrinsic utility element is deducted from his expected costs. In contrast to the model of Fehr & Schmidt (1999) our model does not assume different disutility levels for inequity. After transformation of (1), replacing $\mathrm{F(WF)}$ with its value and including the fairness term, the new optimization problem of farmer 1 is given with:

$$\underset{C_1}{\mathrm{Min}}\, \mathrm{EC}_1(C_1, C_2) = \mathrm{OC}_1 - \frac{\mathrm{WF}}{\mathrm{V}} \cdot (\mathrm{OC}_1 - C_1) + \alpha_1 \cdot (C_1 - C_2)^2 \qquad (2)$$

$$\text{Subject to } \mathrm{WF} = \mathrm{WF}_{t-1} + C_1 + C_2$$

α_1 expresses the inequity aversion parameter of farmer 1. OC_1, the opportunity costs of farmer 1, which depends on the number of livestock he possesses. The second term of equation 2 represents the benefit that farmer 1 gets when he pays his contribution into the water fund, namely the difference between his contribution and his opportunity costs weighted with the probability of the infrastructure not to break down. As long as the individual participation condition holds, the expected costs will be smaller than his opportunity costs, if he contributes $C_1 \geq 0$. This does not mean that the expected costs function is monotonically decreasing for any contribution smaller that the opportunity costs. The optimal contribution of farmer 1 resulting from this decision situation is:

$$C_1 = \frac{\mathrm{OC}_1 - \mathrm{WF}_{t-1} + (\alpha_1 \cdot 2 \cdot \mathrm{V} - 1) \cdot C_2}{(2 + \alpha_1 \cdot 2 \cdot \mathrm{V})}$$

<u>Proposition 1</u>: *If farmer 1 is acting opportunistically, he will decrease his contribution, when the contribution of farmer 2 increases.*

$$C_1 = \frac{\mathrm{OC}_1 - \mathrm{WF}_{t-1} - C_2}{2}$$

Without the fairness norms, $\alpha_1 = 0$, the contribution of farmer 1 would be negatively correlated with the contribution of farmer 2. When farmer 1 computes his optimal decision, he takes the contribution of farmer 2 as given. His expected costs reach the minimum at a certain amount in the water fund. If WF remains constant and the other farmers increase their contribution, farmer 1 must decrease his contribution to reach the minimum of his expected costs. This behavior conflicts with the concept of inequity aversion of Fehr & Schmidt (1999) and conditional cooperation of Fischbacher & Gächter (2010).

<u>Proposition 2</u>: *The higher the livestock number of farmer 1, the higher his contribution into the water fund.*

The farmer's opportunity costs are determined by his number of livestock. Independent from fairness norms he is willing to increase payments if his opportunity costs increase. He strives to avoid higher opportunity costs if the infrastructure breaks down, thus he has an incentive to contribute. The congruence of appropriation (livestock number) and provision (individual contribution) can be observed in this result (Ostrom 2010). A farmer with a high number of livestock will pay more than a farmer with a smaller herd.

Proposition 3: *For* $\alpha_1 > \frac{1}{2 \cdot V}$ *the contribution of farmer 1 is positively correlated with the contribution of farmer 2.*

Due to the uncertainty of the maintenance costs, farmer 1 will increase his contribution, if $\alpha_1 > \frac{1}{2 \cdot V}$. The uncertainty about the maintenance costs gives farmer 2 the possibility to have to pay either C_2 or OC_2. Since farmer 1 is not sure about the final costs for farmer 2, the influence of his fairness factor α_1 will be reduced by the uncertainty of the maintenance costs. If the costs were certain, farmer 1 would increase his contribution for any $\alpha_1 > 0$. In the presence of uncertainty he will, however, decrease or maintain his contribution for $\alpha_1 < \frac{1}{2 \cdot V}$, although he has some disutility resulting from violating his norm of inequity aversion (Fehr & Schmidt 1999, Fischbacher & Gächter 2010).

Our theoretical deliberations allow us to draw first conclusions which we summarize in Table 1. In the case of homogeneous endowments and consequently homogeneous opportunity costs the payments under the norm of inequity aversion are equal to the payments under the norm of conditional cooperation. In this case it is likely that the group will come to an agreement even if they do not share the same norms. In the case of homogeneous norms group members will most likely contribute to the common good even if their contributions exceed their opportunity costs. This can be explained by the fact that they try to avoid the intrinsic disutility resulting from norm violations. This case is consistent with Ostrom's (2005) statement that groups are likely to develop an adequate set of institutions when they share a common set of values.

The risk of failing collective action must be taken into account, however, when there is both a high heterogeneity of endowments/opportunity costs and norms. This is the case when smaller farmers demand a payment according to their appropriation and the richer ones propose equal payments per person. Under this condition the disutility of violating one's norm hinders to come to an agreement and unless process of harmonizing values takes place cooperation will be improbable.

<table>
<tr><td colspan="4">Table 1: Interactions between the heterogeneity of endowments and norms</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Heterogeneity of endowments/opportunity costs</td></tr>
<tr><td>low</td><td>high</td></tr>
<tr><td rowspan="2">Heterogeneity of norms / α</td><td>high</td><td rowspan="2">Payments under norm of inequality aversion
=
Payments under norm of congruence of provision and appropriation</td><td>payments under alternative norms differ and internally perceived costs of breaking norms vary too ➔ risk of failing collective action</td></tr>
<tr><td>low</td><td>payments under alternative norms differ but all participants agree to one norm and breaking the norm would lead to internally perceived costs which are weight against opp. costs</td></tr>
</table>

5 Results of the role plays

In the role plays, 8 out of 14 groups did not come to a reliable agreement and did not follow a clear payment system. One group agreed at the beginning of the experiment to pay per head of livestock but in round two one player defected and the cooperation could not be established again (Appendix 4: group 2). Six groups reliably agreed on a system (Appendix 4: groups 1, 3, 4, 5, 6, 14). Five groups cooperated from the first experiment round on and one group started to cooperate after round four (Appendix 8: group 3). Five groups agreed to the payment scheme per person (Appendix 4: groups 1, 3, 4, 5, 6) while one group switched in the course of the experiment from payment per person to payment per head of livestock (Appendix 4: group 14). There are negative correlations between the gini-coefficient of the livestock possession in a group and the fact that a group came to an agreement.[iii]

31 percent of our players are conditional cooperators increasing their payments if the other group members increase their contributions.[iv] 13 percent of the sample adjusted their payments to their share of the group's livestock herd. Interestingly, the group which agreed on a payment system per head of livestock are not included in the second cluster.[v] They changed the amount to be paid per head of livestock during the experiment, both paying, however, always the identical amount per animal in a particular period. The payments of another 13 percent of the players correlated both with the payments of the other players and the livestock numbers. This is possible if there is a relatively stable relation of livestock numbers amongst the group members. Half of them are unconditional cooperators who made the same contribution in all experiment rounds. The payments of 42 percent of the players neither correlated with the other group members' payments nor their share of the livestock herd. We do not observe consequent free riding or straight opportunistic behaviour, which means that all players contributed to the maintenance of the water infrastructure.

All reliably cooperating groups had only two group members (Appendix 2). All reliably or non-reliably cooperating groups were ethnically homogeneous (Appendix 3).

Analysing the role-plays' contributions using regression models (Table 2) reveals that players with lower livestock numbers tend to make lower contributions. It can be further observed that the higher the contributions of the other group members the higher the own contribution will be. We standardised the two variables to $\mu = 0$ and $\sigma = 1$ and can see that the coefficients are approximately in the same range (0.447 vs. 0.490).

Significantly higher payments were made in experiment rounds when group members came to an agreement. Contributions did not decline over the game periods.[vi] The higher the player's account balance in an experiment period the higher her contribution. The amount in the water fund was taken into consideration by the players. The size of the group did not have a significant impact in individual contributions.

We asked our respondents how many water pumps they have available on their farm and how

Table 2: Random effects regression models explaining the natural logarithm of the individual players' payment for covering the water infrastructure maintenance costs: coefficients and cluster robust standard errors in parenthesis (minimum of dependent variable = 0, maximum = 9.6) (*** p<0.01, ** p<0.05, * p<0.1) N = 45

Variable	Minimum and maximum of variable	Random effects model	model with standardised variables
1) game round t	2 - 9	0.0787** (0.0371)	0.079** (0.037)
2) average payment of other players in all previous rounds	500 - 20880	-0.00005 (0.00008)	-0.130 (0.200)
3) all other group member's payment in t	0 – 8300	0.00020*** (0.00007)	0.447*** (0.159)
4) account balance in group water fund at beginning of t	0 – 28787	-0.00005** (0.00003)	-0.424** (0.208)
5) individual account balance at beginning of t	-494,954 – 414,650	0.000003** (0.000001)	0.368** (0.143)
6) livestock number at beginning of t	0 - 151	0.0152*** (0.0038)	0.490*** (0.122)
7) did the group come to an agreement	0/1	0.761** (0.380)	0.761** (0.380)
8) number of farmers in group	2 – 5	-0.193 (0.143)	-0.193 (0.143)
Constant term		5.344*** (0.847)	6.236*** (0.725)
Number of observations		360	360
Number of individuals		45	45
Number of observations per individual		8	8
Prob > F/chi²		0.0000	0.0000
R^2 within		0.1172	0.1172
R^2 between		0.4273	0.4273
R^2 overall		0.2644	0.2644
Wooldridge test for autocorrelation Prob > F		0.3281	0.3281
Robust Hausman test Prob > F		0.2892	0.2892
		legend: * p<0.10 ** p<0.05; *** p<0.01;	

many pumps are indeed working. There is a correlation between the total water payments of a group and the share of the operating water infrastructure.[vii]

6 Discussion and conclusion

The explorative assessment of the social-ecological systems of land reform projects shows that arbitrarily mixed groups of farmers are facing the challenge to solve the provision problem of a common pool resource. They can therefore not build on a long-enduring history of CPR management. The situation is aggravated if the newly formed groups are ethnically heterogeneous. In our small sample no mixed group came to an agreement. Forcing ethnically mixed groups into cooperation situations might support nation building and potentially help to overcome tribalism, but in the short run the heterogeneity of norms makes it more difficult to establish a stable fundament of social capital. In our experiment only ethnically homogeneous groups came to an agreement. At the same time we observe that groups which came to an agreement made significantly higher payments.

The most commonly used payment systems of rural water supply in Namibia are payment per head of livestock and payment per person (Bock et al. 2006, Falk et al. 2009). The two systems differ with regard to the congruence between provision and appropriation, which, according to Ostrom (2010), affects the probability of successful common pool resource management. The provision and appropriation is most congruent under the rule to pay per head of cattle, because livestock is consuming the greatest share of water provided by rural water pumps in Namibia (Bock et al. 2006, Falk et al. 2009). A payment system where each group member pays an equal amount is more in line with fairness norms of conditional cooperation, which, according to Fischbacher & Gächter (2010), supports cooperation.

We observe in our games that the fairness norm of conditional cooperation is more widespread than the one of achieving congruence between provision and appropriation. In our experiment only 1 out of 14 groups has chosen to pay per animal. The regression model reveals, however, that even if the players did not agree on a clear payment system per head of livestock the ones owning more livestock tend to make higher contributions. Five groups shared the costs equally. The system to pay equal amounts achieves a relatively high congruence of provision and appropriation if the gini-coefficient of livestock possession is low in a group. Since the payments under the norm of congruence of provision and appropriation and the one of conditional cooperation match in groups with a relatively equal distribution of endowments, these groups more probably cooperate. In our experiment there is a correlation between choosing the equal payment rule and the gini-coefficient of livestock possession in the group.

We observe that more homogeneous groups in terms of endowments and ethnicity came more probably to an agreement (see also Bardhan 1993, Meinzen-Dick et al. 1997). At the same time, groups which came to an agreement made higher payments. We tried to test the interaction between endowment and norm heterogeneity using interaction terms but the results were unsatisfactory due to high multicolinearity. As a result we can not draw final conclusions about this interaction. Further research is needed.

Our role-plays based on social-ecological modelling simulated a real life cooperation situation. The virtual environment was sufficiently similar to reality but simple enough to be played (Gurung et al., 2006). In this way we increase the potential to learn from the experiment about the real life behaviour of the players. Using the terminology of Roe & Just (2009) we increase our ecological validity as the extent to which the context of the research is similar to the context of interest. As a consequence, the possibility to replicate our results is limited. There is a high probability of the presence of uncontrolled variation in unobserved variables. We also have only restricted control over subject characteristics but play the game with the subjects who are in the centre of the context of interest in order to make statements specifically about their behaviour. We see it as an indicator for the success of our approach that individuals which made higher payments in the role plays manage in real life to keep the infrastructure given to them in better conditions.

The simulation model based role-plays produced not only knowledge but provided support to stakeholders in their decision making (Barreteau et al., 2001; Barreteau, 2003; Gurung et al., 2006; Guyot & Honiden, 2006; Becu et al., 2008). There was uniform response from the participants that they perceived the exercise as training rather than a research activity. Gurung et al. (2006) emphasizes that one key objective of participatory modelling is to facilitate dialogue, shared learning, and collective decision making through interdisciplinary research to strengthen the adaptive management capacity of local communities. Modelling in combination with role plays is a tool to play with rules and strategies and in this way explore probable ecological and economical consequences. It limits the costs of trial and error methods and shifts the approach from costly learning by doing towards learning by simulating (Barreteau et al. 2001). Our approach simultaneously deepens the understanding of cooperation processes and serves as a tool to encourage discussion and institution building. In this sense, we supported Namibian land reform beneficiaries in a current and relevant challenge.

Which policy implications can be drawn from our research? First of all, the research confirms the ongoing challenge of institution building faced by land reform beneficiaries. This is not a short term issue anymore as some of the beneficiaries have been resettled more than 20 years ago (mean = 9 years). Considering the importance of water supply for farming in Namibia, pre- and post-resettlement support should not only pay attention to technical aspects of water infrastructure but should facilitate as well the process of institution building. Larger groups of farmers and less homogeneous ones in terms of endowments and ethnic origin need special attention. We further learned that there are no uniform fairness norms. Achieving congruence between provision and appropriation provides most reliable material incentives to cooperate. Nonetheless, any distribution of the expected costs works as long as the group reliably agrees to it. The intention should therefore not be to impose specific rules on groups but help them to harmonize their norms.

7 Acknowledgement

This study was part of the BIOTA project, which was funded by the German Federal Ministry for Education and Research. We thank Michael Kirk, the coordinator of the BIOTA governance subproject, for his dedicated support. Special acknowledgement goes to all surveyed communities for their time, assistance and hospitality. The study was conducted in cooperation with Bertus Kruger coordinating the Emerging Commercial Farmer Support Programme and Richard Kamukuenjandje lecturing at the Polytechnic of Namibia. We thank all student assistants who contributed to the study, in particular Reinhold Kambuli, Pombili Sheehama, Linnéa Koop, Nora Heil, Lisa Lebershausen, Daniela Neu, Anne Frank, and Muhammad Aneeque Javaid.

---

[i] There has been no random allotment of farm units.

[ii] There are several explanations why communication supports cooperation. Balliet (2011) mentions in particular receiving signals about other’s willingness to cooperate, group identity and the development of shared norms.

[iii] Spearman rank correlation for variables “group came to agreement” and “gini-coefficient of livestock possession of group”: coefficient: -0.3808, p=0.000, N=14;

[iv] Where there is a correlation between the own payment and the payments of the rest of the group in a particular experiment period (Pearson correlation calculated and considered to be correlated if p<0.05).

[v] Where there is a correlation between the own payment and the share of the individual on the total livestock number of their group in a particular experiment period (Pearson correlation calculated and considered to be correlated if p<0.05).

[vi] We excluded the last game round in order to avoid any possible end round effects.

[vii] Spearman rank correlation for variables "total individual payment over all game periods" and "operating share of total infrastructure": coefficient: 0.3179, p= 0.0378, N=43;

References

Baland, J.-M., Platteau, J.-P. (1996) Halting degradation of natural resources, Published by the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

Balliet, D. P. 2010. Communication and Cooperation in Social Dilemmas: A Meta-Analytic Review. Journal of Conflict Resolution, 54(1): 39-57.

Bardhan, P. (1993): Analytics of the Institutions of Informal Cooperation in Rural Development; World Development; Vol. 21/4: 633-639.

Barreteau, O.; Bousquet, F.; Attonaty, J.-M. (2001): Role-playing games for opening the black box of multi-agent systems: method and lessons of its application to Senegal River valley irrigated systems; Journal of Artificial Societies and Social Simulations; Vol. 4, No. 2.

Barreteau, O. (2003): Our companion modelling approach; Journal of Artificial Societies and Social Simulations; Vol. 6, No. 1.

Becu, N.; Neef, A.; Schreinemachers, P.; Sangkapitux, C. (2008): Participatory computer simulations to support collective decision-making: Potential and limits of stakeholder involvement; Land Use Policy 25: 498-509.

Binmore, K.; Shaked, A. (2010): Experimental economics: Where next?; Journal of Economic Behaviour and Organisation; Vol. 73: 87-100.

Bock, B. and Kirk, M. 2006. Rural water pricing systems in Namibia: Effects on water use and livelihoods. Quarterly Journal of International Agriculture 45(4): 339-360.

Bousquet, F., O. Barreteau, P. d'Aquino, M. Etienne, S. Boissau, S. Aubert, C. Le Page, D. Babin and J.-C. Castella (2002) Multi-agent systems and role games: collective learning processes for ecosystem management. In M.A. Janssen (ed.) Complexity and Ecosystem Management: The Theory and Practice of Multi-agent Systems, pp. 248–85. Cheltenham: Edward Elgar.

Buckley, E. & Croson, R. (2006): Income and wealth heterogeneity in the voluntary provision of linear public goods; Journal of Public Economics; Volume 90(4-5): 935-955.

Cardenas, J. C. and Carpenter, J. (2008). Behavioural development economics: lessons from field labs in the developing world. Journal of Development Studies, 44, 337–64.

Cummins, R. A. (1996). The domains of satisfaction: an attempt to order chaos. Social Indicators Research 38(3):303-328.

Deininger, K., and G.Feder. 2009. Land Registration, Governance, and Development: Evidence and Implications for Policy. The World Bank Research Observer 24(2). Oxford University Press, Washington, D.C. USA.

Falk, T.; Bock, B.; Kirk, M. (2009): Polycentrism and poverty: Experiences of rural water supply reform in Namibia. Water Alternatives 2(1): 115-137.

Falk, T., Kruger, B., Lohmann, D., Kamukuenjandje, R., Zimmermann, I., Kirk, M., Hindjou, J., Kambuli, R., Sheehama, P., Koop, L., Heil, N., Lebershausen, L., Neu, D., Frank, A. (2010): Economic and ecological indicators of land reform projects in eastern Namibia. In: Jürgens, N. et al. (eds.): Biodiversity in southern Africa. Volume 2: Patterns and processes at regional scale. Klaus Hess Publishers, Göttingen & Windhoek

Falk, T., Vollan, B., Kirk, M. (2012). Analysis of material, social, and moral governance in natural resource management in southern Namibia. International Journal of the Commons, Available at: <http://www.thecommonsjournal.org/index.php/ijc/article/view/307/266>. Date accessed: 24 May. 2012.

Fehr, E. & Schmidt K. M. (1999): A Theory of Fairness, Competition, and Cooperation; The Quarterly Journal of Economics; Vol. 114, No. 3: 817-868.

Fischbacher, U., Gaechter, S. & Fehr, E. 2001 Are people conditionally cooperative? Evidence from a public goods experiment. *Econ. Letters* 71, 397–404.

Fischbacher, Urs, and Simon Gachter. 2010. "Social Preferences, Beliefs, and the Dynamics of Free Riding in Public Goods Experiments." *American Economic Review*, 100(1): 541–56.

Gurung, T.R.; Bousquet, F.; Trébuil, G. (2006): Companion modelling, conflict resolution, and institution building: sharing irrigation water in the Lingmetuychu watershed, Bhutan; Ecology and Society 11(2): 36.

Guyot, P.; Honiden, S. (2006): Agent-based participatory simulations: merging multi-agent systems and role-playing games; Journal of Artificial Societies and Social Simulations; Vol. 9, No. 4.

Hardin, G. (1994): The Tragedy of the Unmanaged Commons; Trends in Ecology & Evolution 9: 199-199.

Lohmann, D.; Tietjen, B.; Blaum, N.; Joubert, D.F.; Jeltsch, F. (accepted): Shifting thresholds and changing degradation patterns: Climate change effects on the simulated long-term response of a semi-arid savanna to grazing; Journal of Applied Ecology

Meinzen-Dick, R. S., Mendoza, M. S., Saddoulet, L.,Abiad-Shields, G., & Subramanian, A. (1997). Sustainable water user associations: Lessons from a literature review. In A. Subramanian, N. V. Jagannathan, R. S. Meinzen-Dick (Eds.), User organizations for sustainable water services (pp. 7–87). World Bank Technical Paper 354. Washington, DC: World Bank.

Mendelsohn, J., and A. Jaris, C. Roberts, T. Robertson. 2002. Atlas of Namibia. David Philips Publishers, Cape Town, South Africa.

Mendelsohn, J. (2006): "Farming Systems in Namibia", Research and Information Service Nambia, Windhoek.

Nowak, M.A. (2006) Five Rules for the Evolution of Cooperation; Science 314: 1560-1563.

Olson, Mancur (1965). The Logic of Collective Action. Harvard University Press.

Ostrom, E. (1998) A Behavioral Approach to the Rational Choice Theory of Collective Action: The American Political Science Review , Vol. 92, No. 1, pp. 1-22

Ostrom, E. 2005. Understanding Institutional Diversity. Princeton: Princeton University Press.

Ostrom, E. 2007. A Diagnostic approach for going beyond panaceas. Proceedings of the National Academy of Science of the United States of America Vol. 104 No. 39: 15181-15187.

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science 325:419-422.

Ostrom, E. (2010): Beyond markets and States: Polycentric Governance of Complex Economic Systems; American Economic Review 100: 641-672.

Popp,A., Vogel, M., Blaum, N. & Jeltsch, F. (2009) Scaling up ecohydrological processes: Role of surface water flow in water-limited landscapes. Journal of Geophysical Research-Biogeosciences 114.

Poteete, A. R. and Ostrom, E. (2004), Heterogeneity, Group Size and Collective Action: The Role of Institutions in Forest Management. Development and Change, 35: 435–461.

Roe, Brian and David R. Just. "Internal and External Validity in Economics Research: Tradeoffs between Experiments, Field Experiments, Natural Experiments and Field Data." American Journal of Agricultural Economics Vol. 91 No. 5 (2009).

RoN/Republic of Namibia. 1995a. Agricultural Commercial Land Reform Act No. 6, Windhoek, Namibia.

RoN/Republic of Namibia. 2002. Notification No. 219 of farming units offered for allotment according to the Agricultural (Commercial) Land Reform Act, 1995, Government Gazette, Windhoek.

Rustagi, D., Engel, S. and Kosfeld, M. 2010. Conditional Cooperation and Costly Monitoring Explain Success in Forest Commons Management. *Science* , 330, 961 - 965.

Smith, A. [1789] 2004. Theorie der ethischen Gefühle (Theory of ethic feelings). Hamburg: Felix Meiner Verlag.

Sterman, J. D. (2006) Learning from Evidence in a Complex World. *American Journal of Public Health,* 96**,** 505-514.

Tietjen,B., Jeltsch, F., Zehe, E., Classen, N., Groengroeft, A., Schiffers, K. & Oldeland, J. (2010) Effects of climate change on the coupled dynamics of water and vegetation in drylands. Ecohydrology 3, 226-237.

Tietjen,B., Zehe, E. & Jeltsch, F. (2009) Simulating plant water availability in dry lands under climate change: A generic model of two soil layers. Water Resources Research 45.

Varughese, G., Ostrom, E. (2001) The Contested Role of Heterogeneity in Collective Action: Some Evidence from Community Forestry in Nepal, World Development, Volume 29, Issue 5, pp 747-765.

Vollan, B. 2008. Socio-ecological explanations for crowding-out effects from economic field experiments in southern Africa. *Ecological Economics* 67(4):560-573.

Werner, W., and Odendaal, W. 2010: Livelihoods after land reform – Namibia country report, John Meinert Printing, Windhoek, Namibia

Appendices

Appendix 1: The ecological-economic model

This Appendix describes the model version that has been used for the field experiments. The descriptions already include all adaptations that are needed for the interactive application. A detailed formal description of the applied sub-models can be found in Tietjen et al. (2009), Tietjen et al. (in review), and Lohmann et al. (in prep).

General structure

The application is based on two linked simulation models. Firstly, we adopted an existing eco-hydrological vegetation model (Tietjen et al., 2010, Lohmann et al. submitted) to the specific needs and conditions of this study, scaled up the resulting vegetation dynamics to the relevant spatial scales for rangeland management by using a state-and-transition approach Secondly, we linked that model to an economic farm model, simulation cattle individual and herd dynamics as well as running costs of the business.

This whole framework is used to conduct role-plays (computerized experiments) with land reform beneficiaries. By using this approach, we can analyze the farmers' behaviour based on scenarios that reflect our scientific understanding of the underlying systems' dynamics. In the following paragraphs we explain the different sub-models, the user interface and the schedule of the program during the role plays.

Ecological-economic model

Our spatially explicit, grid-based model describes horizontal and vertical surface water and soil moisture dynamics in two soil layers as well as vegetation dynamics of different grasses and woody vegetation. (Tietjen et al. 2010, Lohmann et al submitted). This eco-hydrological model calculates the productivity and ecological state of the ecosystem depending on the rainfall, the land use decisions and the environmental conditions. While environmental conditions, i.e. temperature and precipitation, are given as external scenarios, land use strategy is not simulated by the model version used here, but depends on input of the role-players at every time step.

The economic sub- model simulates the processes on a cattle farm assuming proper spatial management of the land such as spatially homogeneous grazing pressure. Hereby we consider animal growth, herd dynamics, running costs of the business and revenues from animal trading.

The individual growth of the animals is not calculated explicitly. Instead we calculate an average quasi weight score per individual based on the grass biomass availability assuming that all individuals are adult cows and that the animals' biomass uptake is higher when biomass availability is higher. This can result in varying uptake rates during the year, with a high probability to lose weight at the end of a season. The result of the average weight score calculation is then transferred to animal state classes. These classes distinguish between animals from a very lean (body score 1) to a fat condition (body score 5) according to the Emerging Commercial Farmer Support Programmes' (ECFSP) definition. The body score classification is based on a commonly used classification system developed by Namibian rangeland experts. The score is communicated to the farmers and used as an argument for other functions of the model.

Animal numbers are influenced by simulated basic herd dynamics as well as by the farmers' decision regarding what animals to sell or buy. Birth, weaning of calves, age and disease related mortality as well as starvation are the processes determining the herd dynamics. Livestock starves if there is not enough biomass to support the given number of animals. Individuals that reach the maximum age are assumed to be culled. The processes of herd dynamics depend on the animal state. The parameter values for these traits have been derived from data given by the Sandveld research station of the Namibian Ministry of Agriculture, Water, and Forestry.

The costs that need to be covered are calculated on the basis of simple rules so that we have relatively neutral and equal conditions for every run of the simulation game. We distinguished between fixed costs being dependent on the farm size and variable costs being dependent on the number of livestock. Both cost functions are assumed to be linear. In addition, the water related costs are derived by randomly drawing a value from a normal distribution. The mean of the water cost function is the empirical average maintenance cost of water points given by the Namibian government's Directorate of Rural Water Supply (Bock and Kirk, 2006). For the analyses of the cooperation behaviour we assumed that a group of farmers share one wind driven and one diesel driven water pump.

We assume stable livestock prices over the simulated years. Variations according to the season of the year, between buying and selling prices as well as for different types of livestock are considered and derived from the database of the Meat Board of Namibia. Interests for positive as well as negative account balances are calculated.

Appendix 2: Crosstabulation for number of group members and group coming to agreement *(absolute frequencies of groups with relative frequencies in parantheses)*

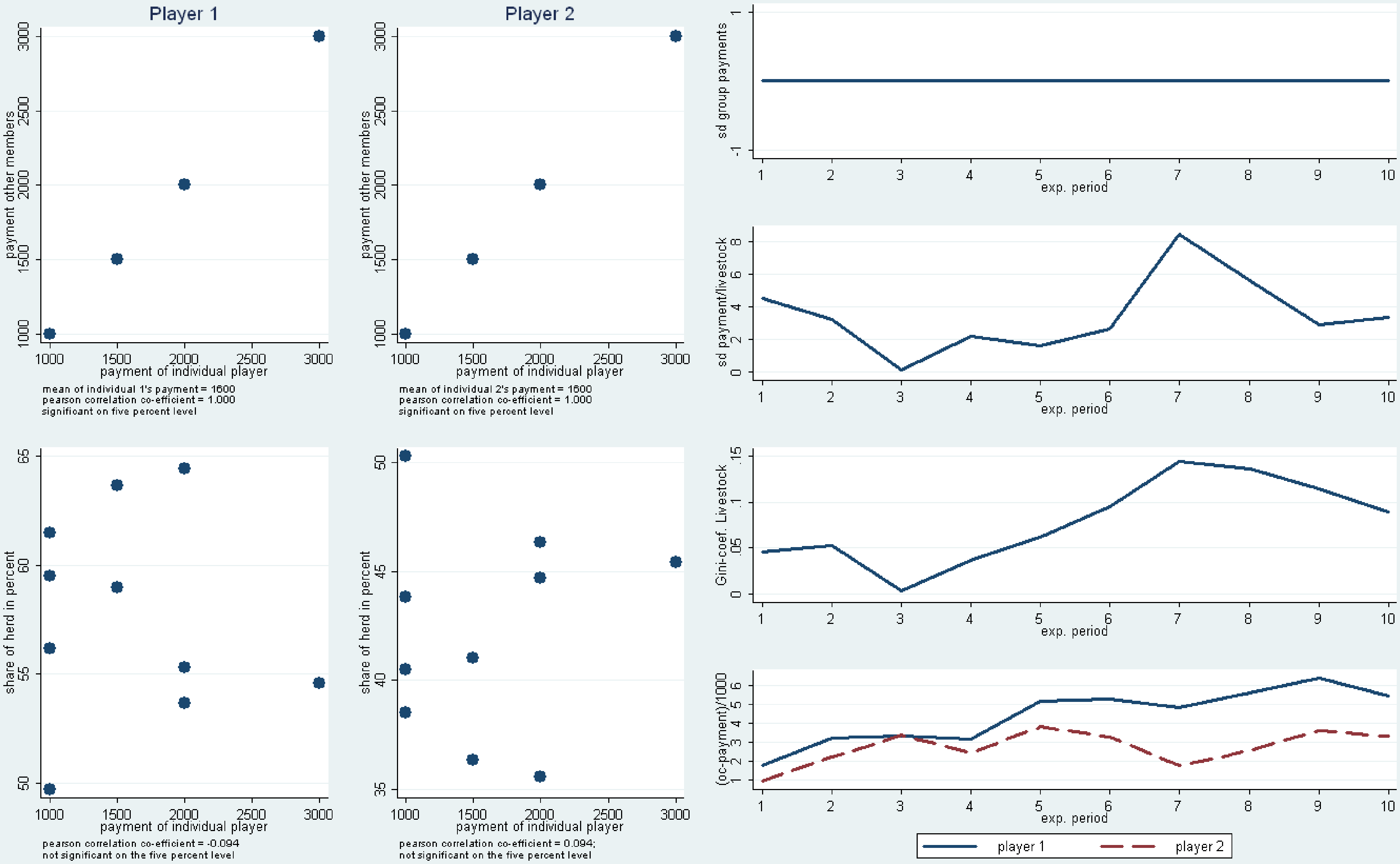
	number of farmers in group					Total
	2	3	4	5	6	
no agreement	1 (7.14%)	2 (14.29%)	1 (7.14%)	3 (21.43%)	0 (0.00%)	8 (57.14%)
came to agreement	6 (42.86%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (7.14%)	6 (42.86%)
Total	7 (50.00%)	2 (14.29%)	1 (7.14%)	3 (21.43%)	1 (7.14%)	14 (100.00%)

Appendix 3: Crosstabulation for ethnic heterogeneity and group coming to agreement *(absolute frequencies of groups with relative frequencies in parentheses)*

	number of ethnic groups in group			Total
	1	2	3	
no agreement	1 (7.14%)	3 (21.43%)	3 (21.43%)	8 (57.14%)
came to agreement	6 (42.86%)	0 (0.00%)	0 (0.00%)	6 (42.86%)
Total	8 (57.14%)	3 (21.43%)	3 (21.43%)	14 (100.00%)

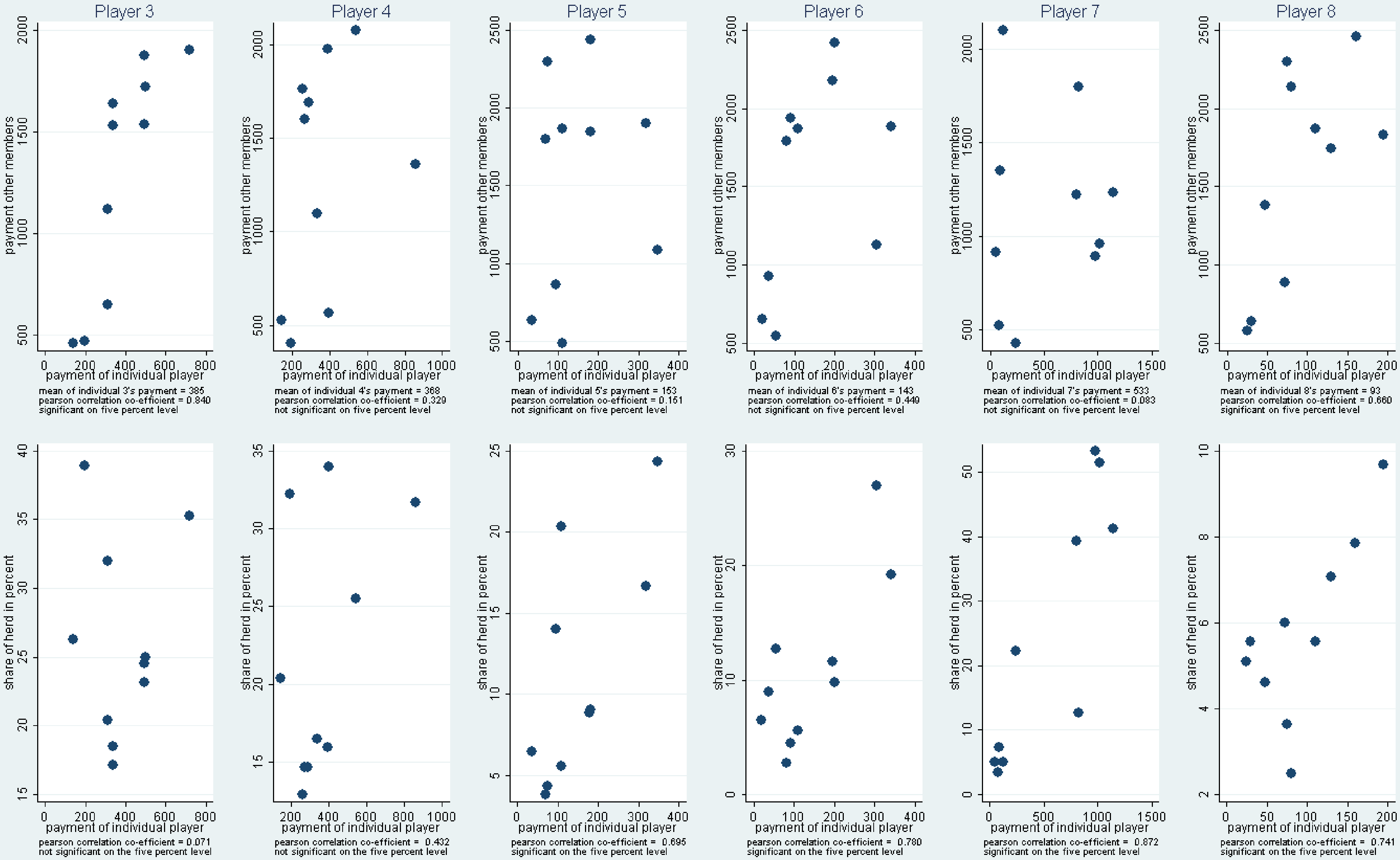
Appendix 4: Figures of group 1

2 members; 1 ethnic group



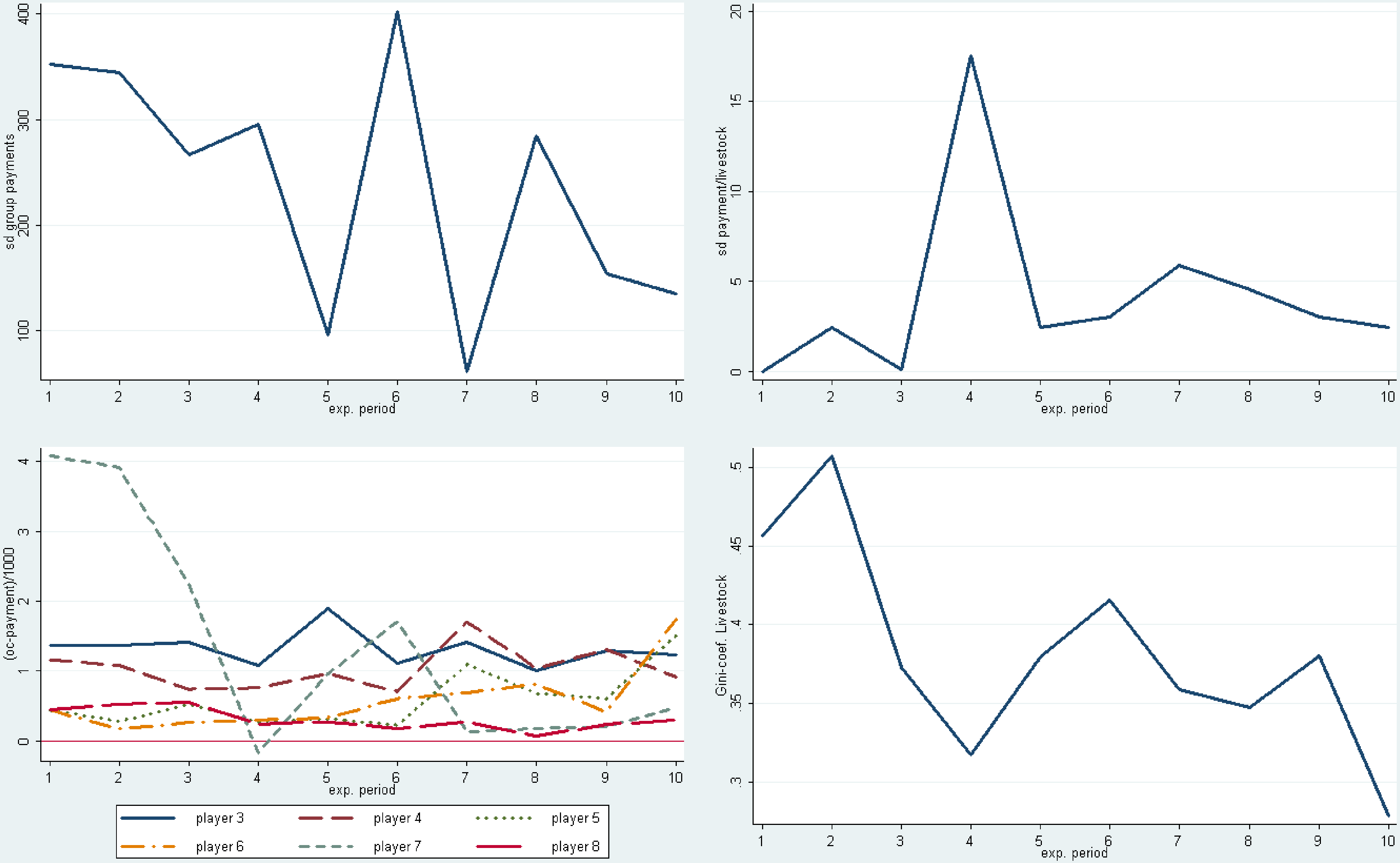
Appendix 4: Figures of group 2a

6 members; 1 ethnic group



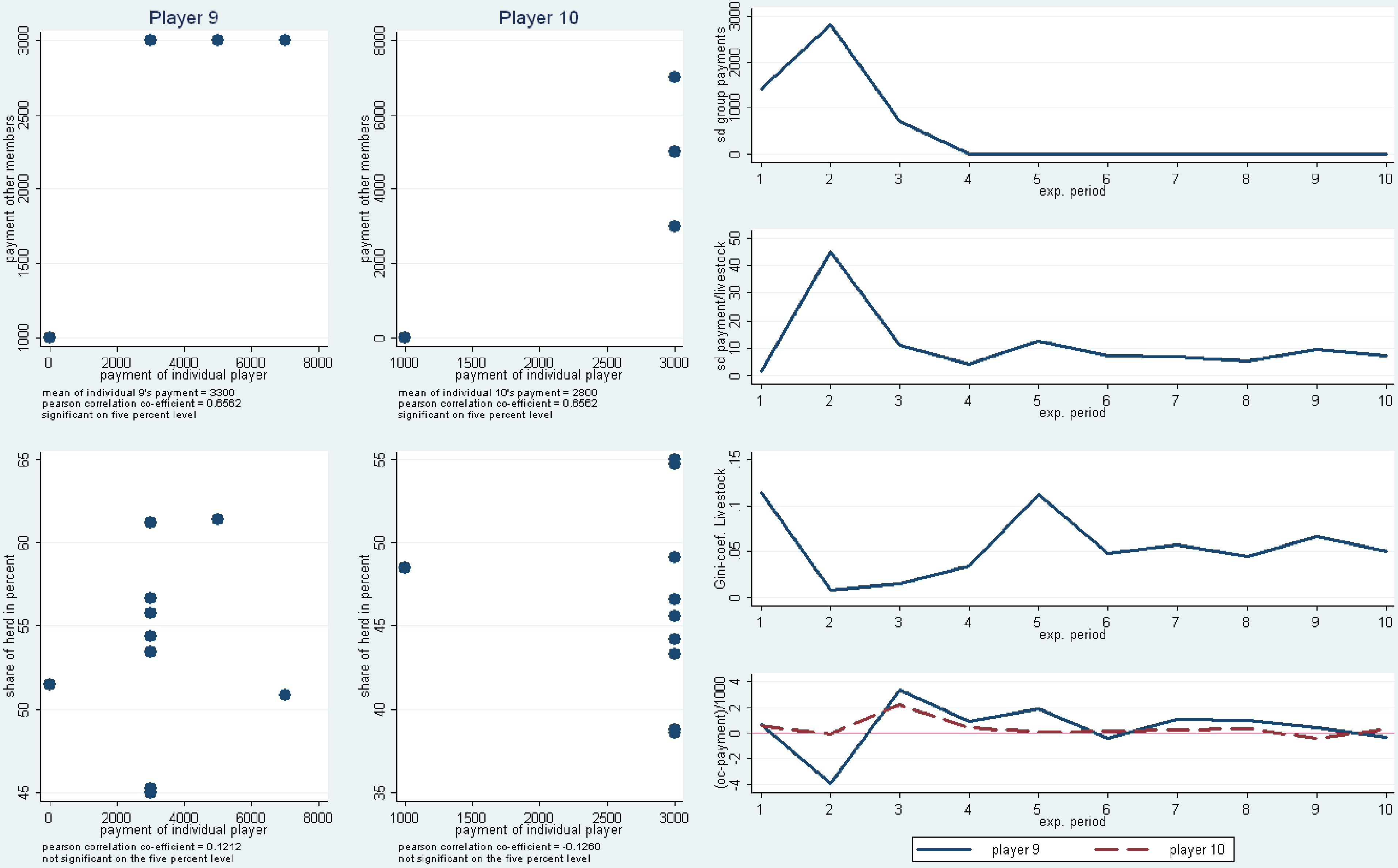
Appendix 4: Figures of group 2b

6 members; 1 ethnic group



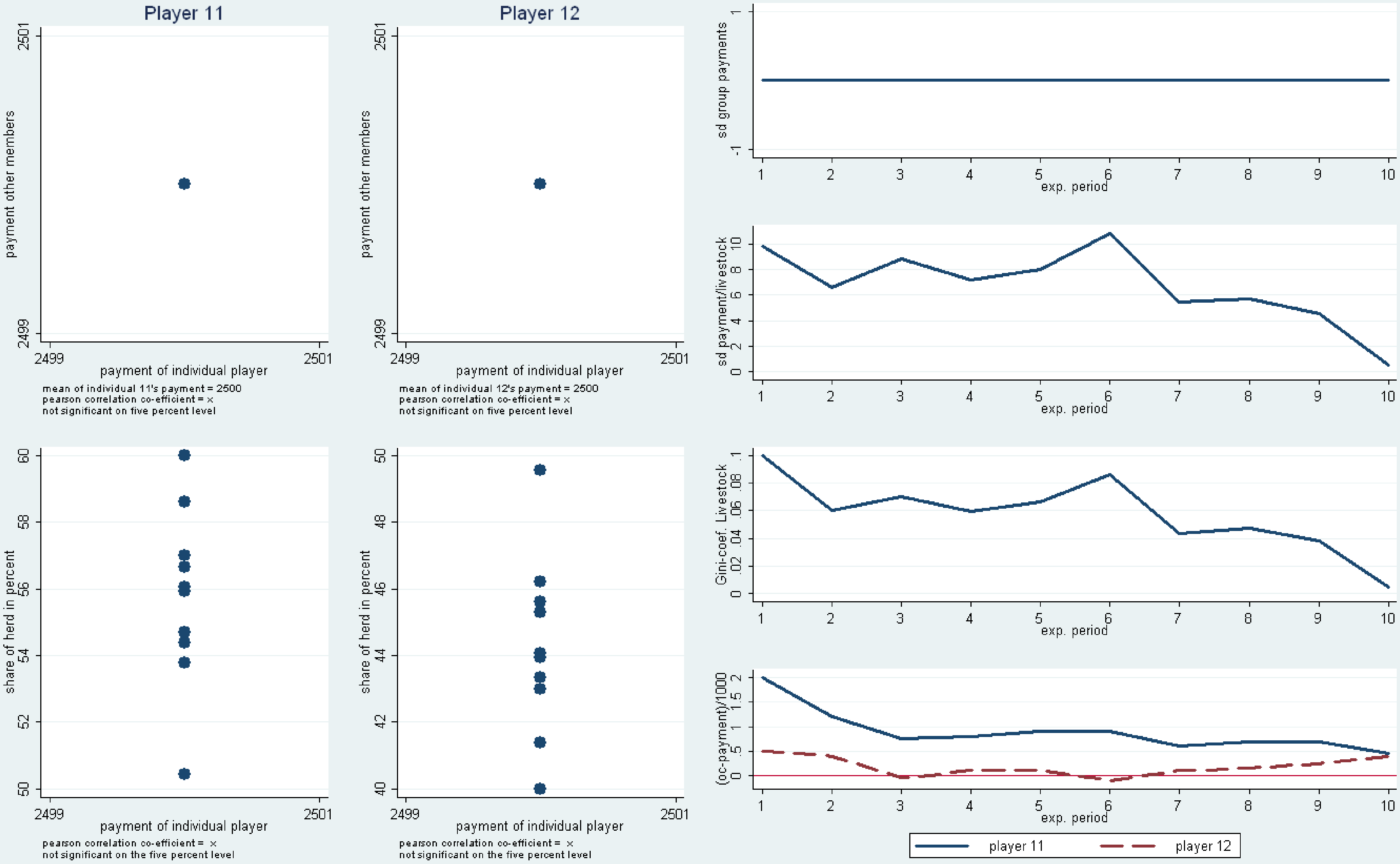
Appendix 4: Figures of group 3

2 members; 1 ethnic group



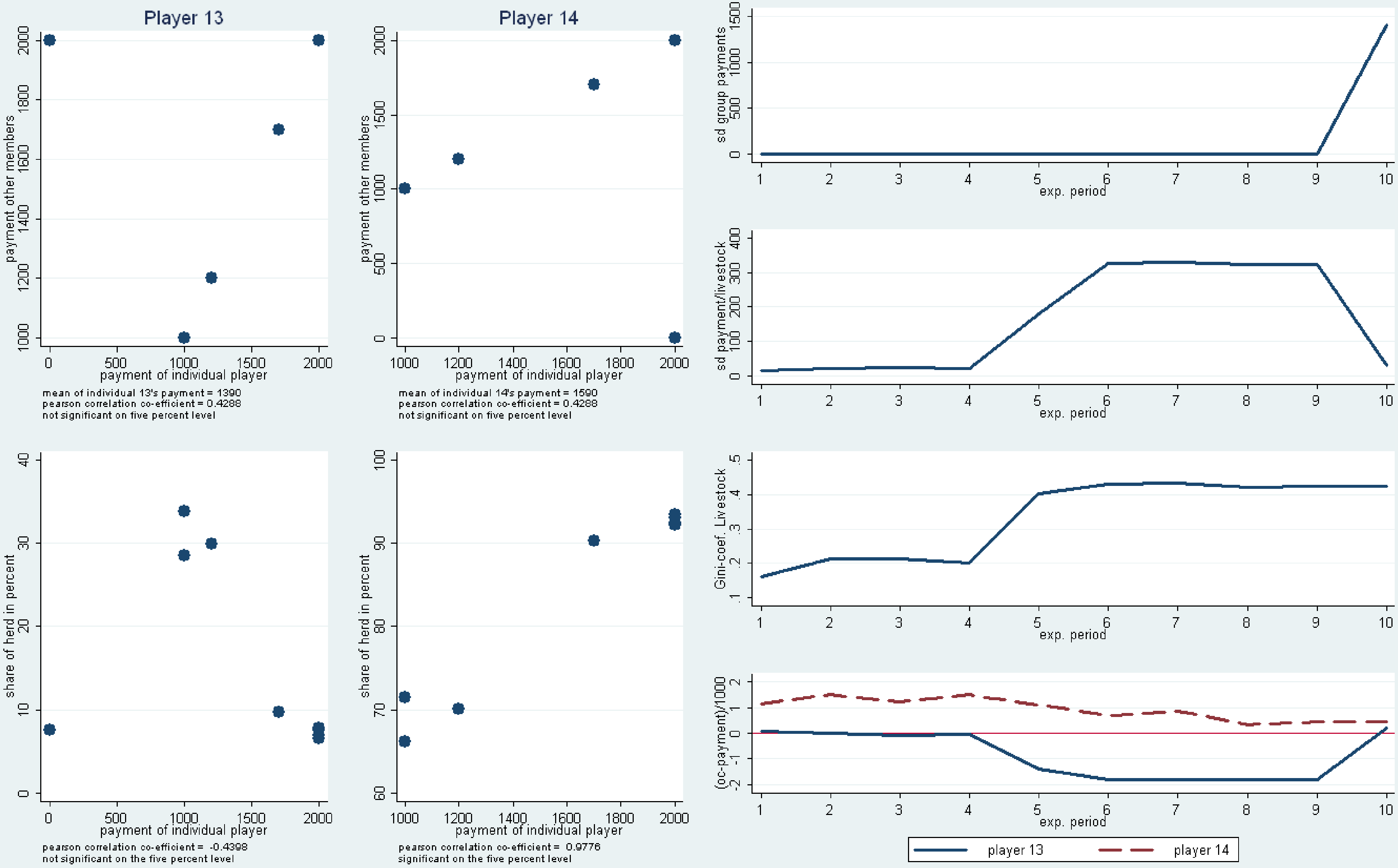
Appendix 4: Figures of group 4

2 members; 1 ethnic group



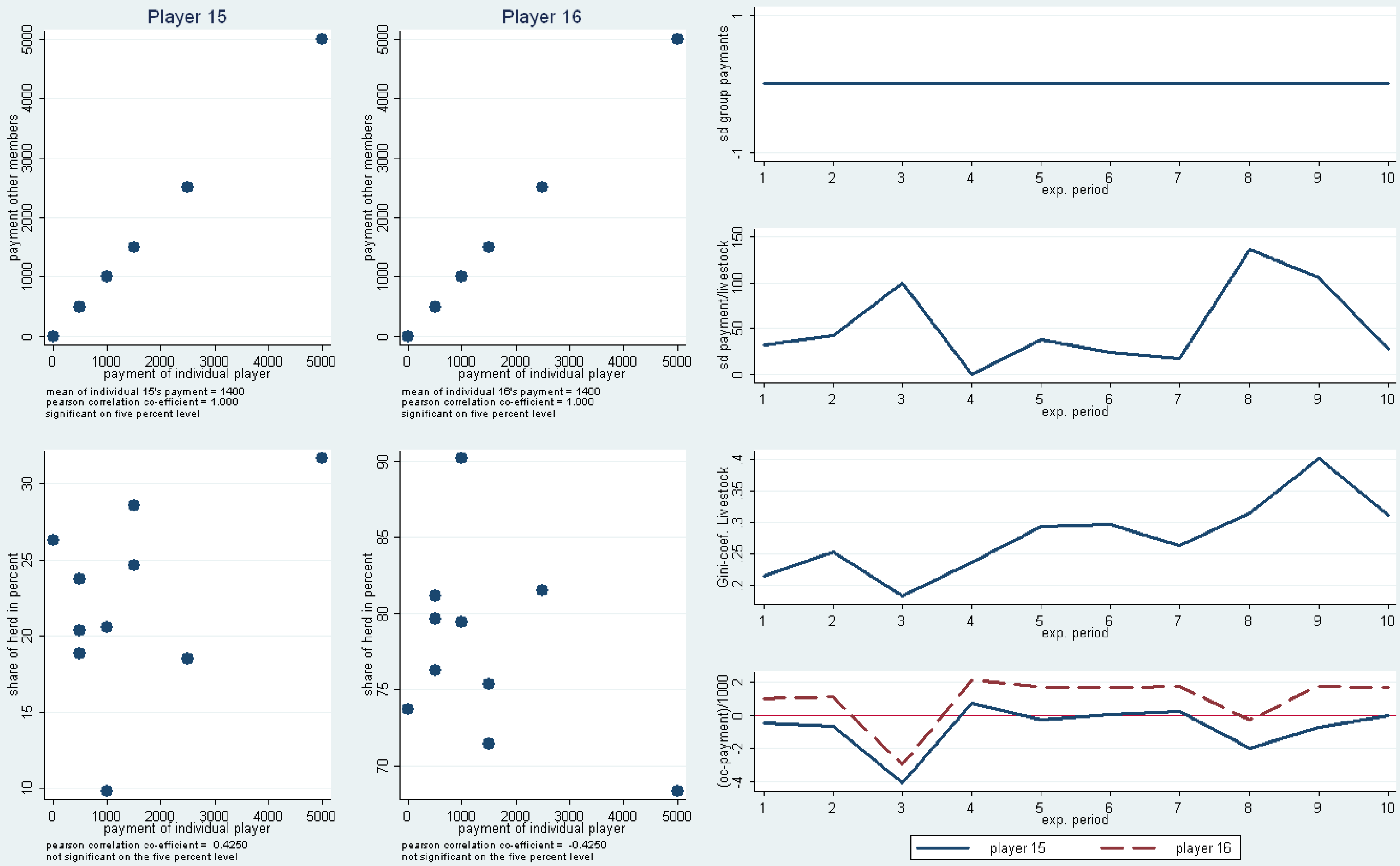
Appendix 4: Figures of group 5

2 members; 1 ethnic group



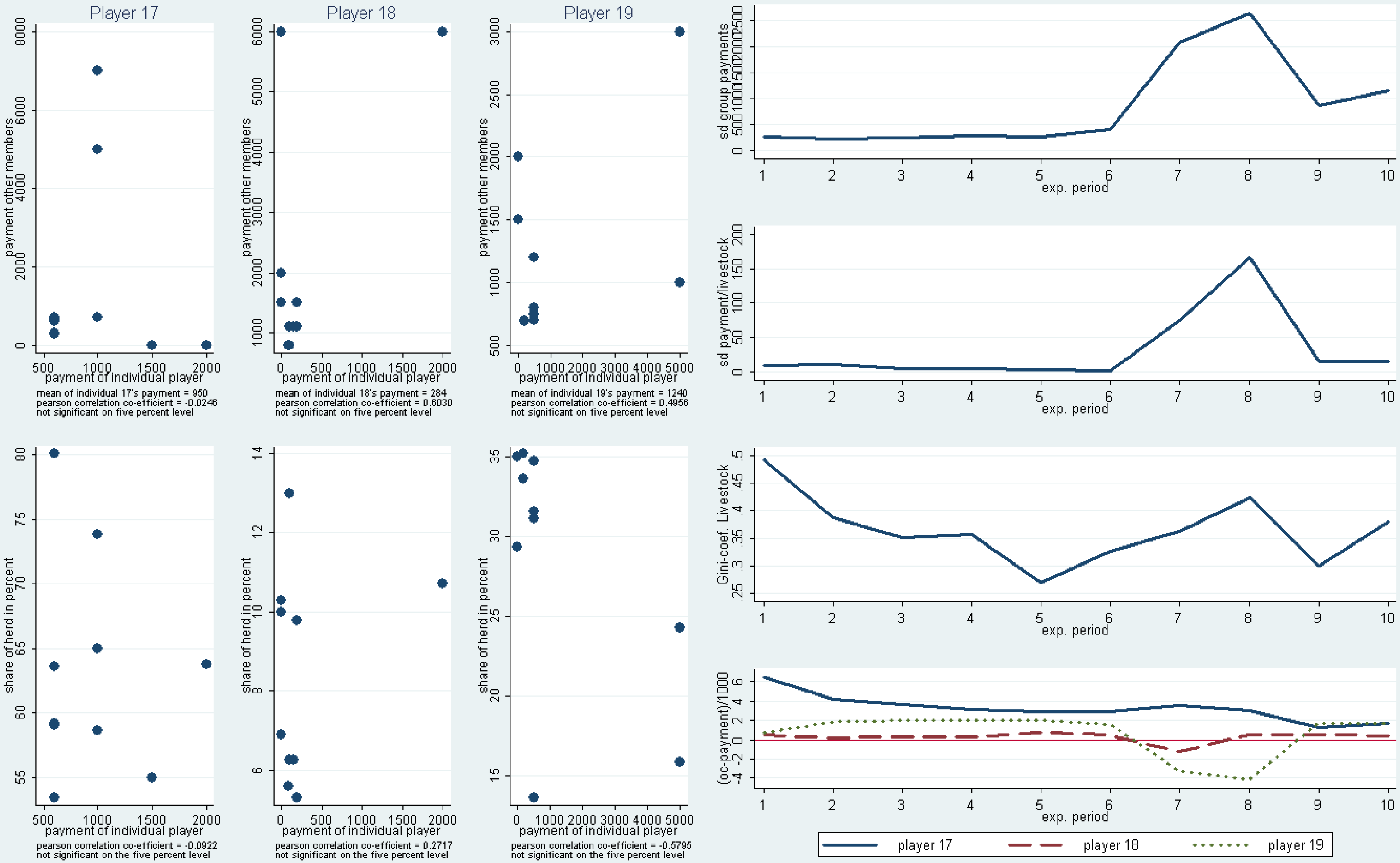
Appendix 4: Figures of group 6

2 members; 1 ethnic group



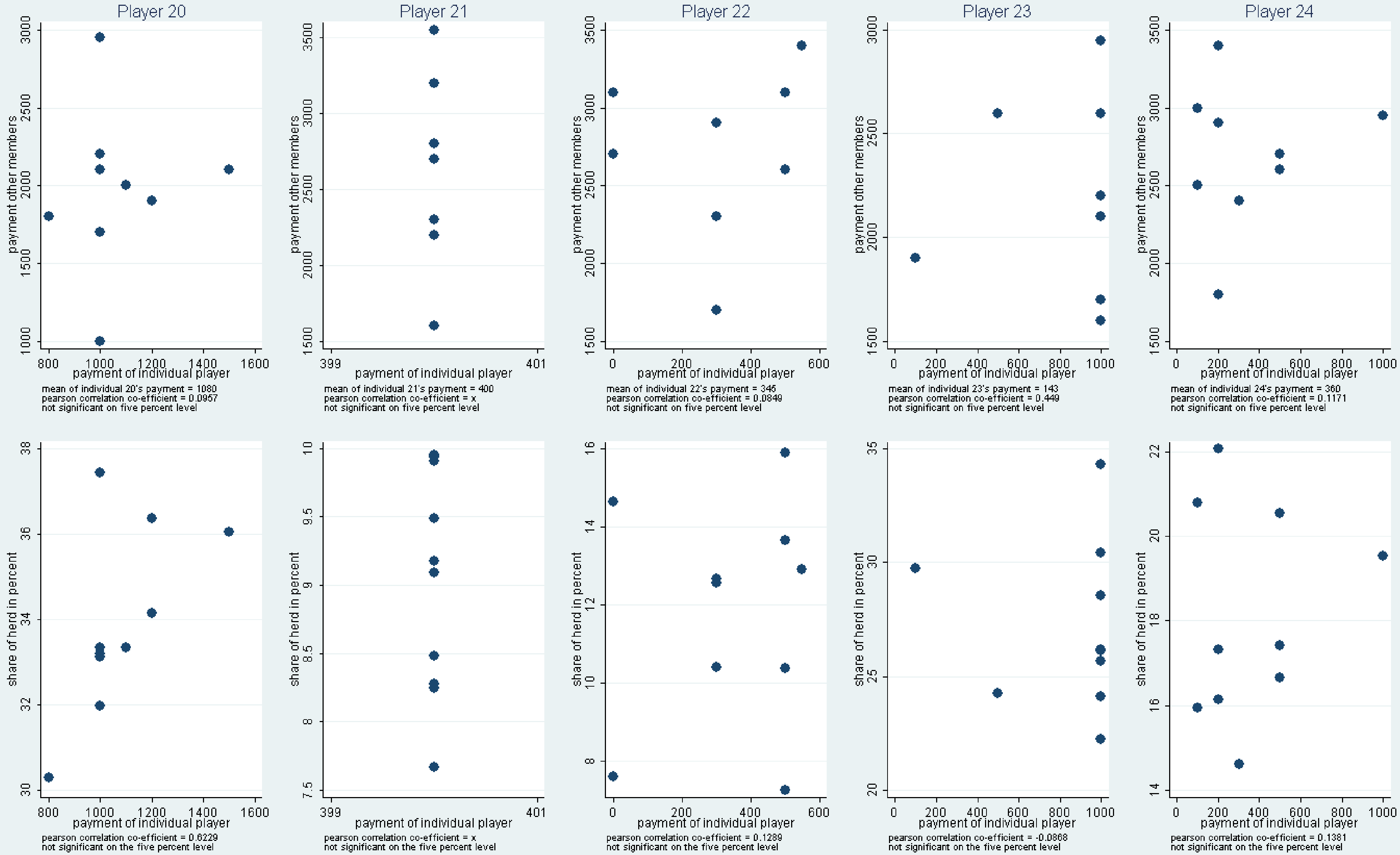
Appendix 4: Figures of group 7

3 members; 2 ethnic group

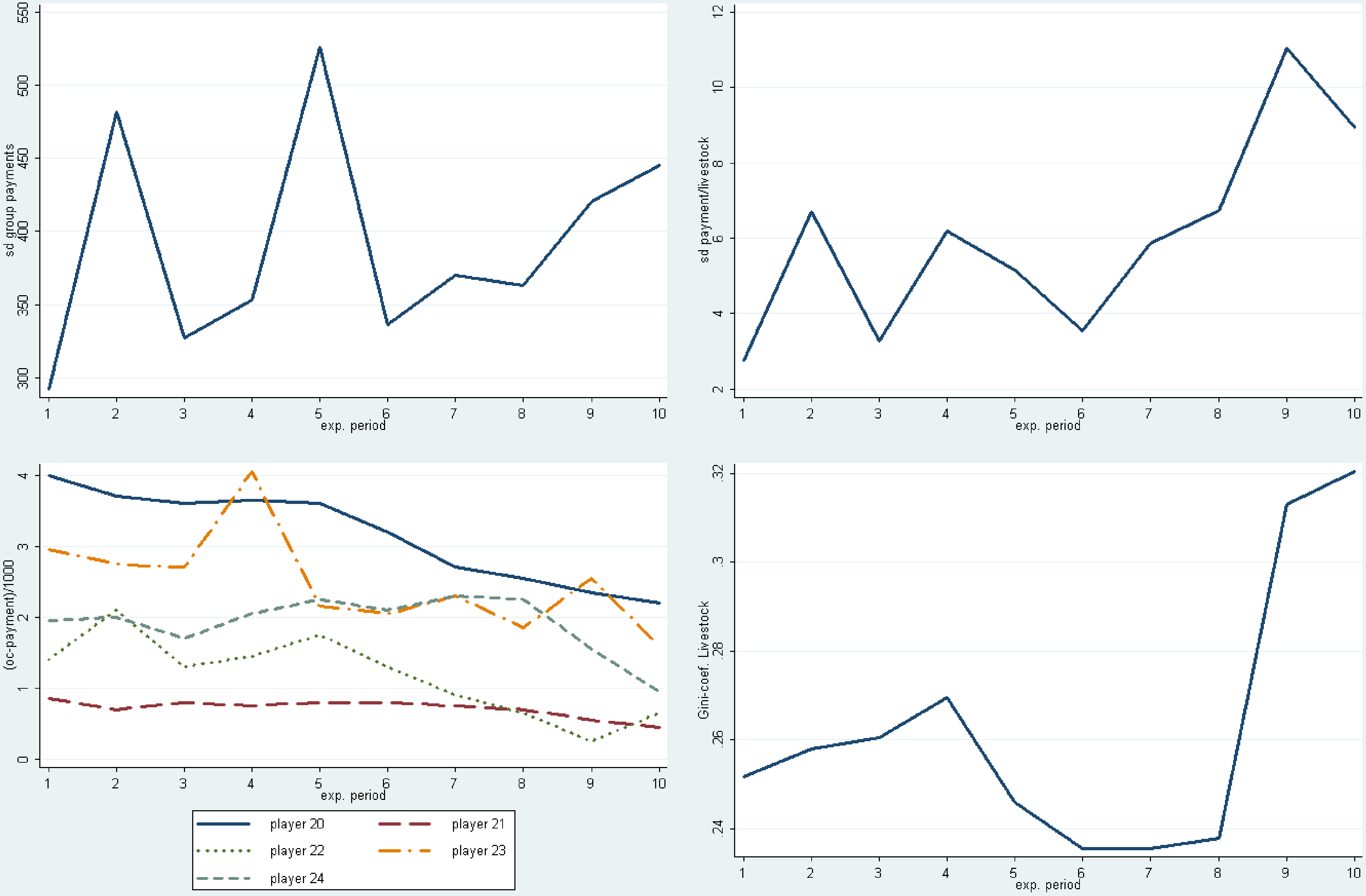


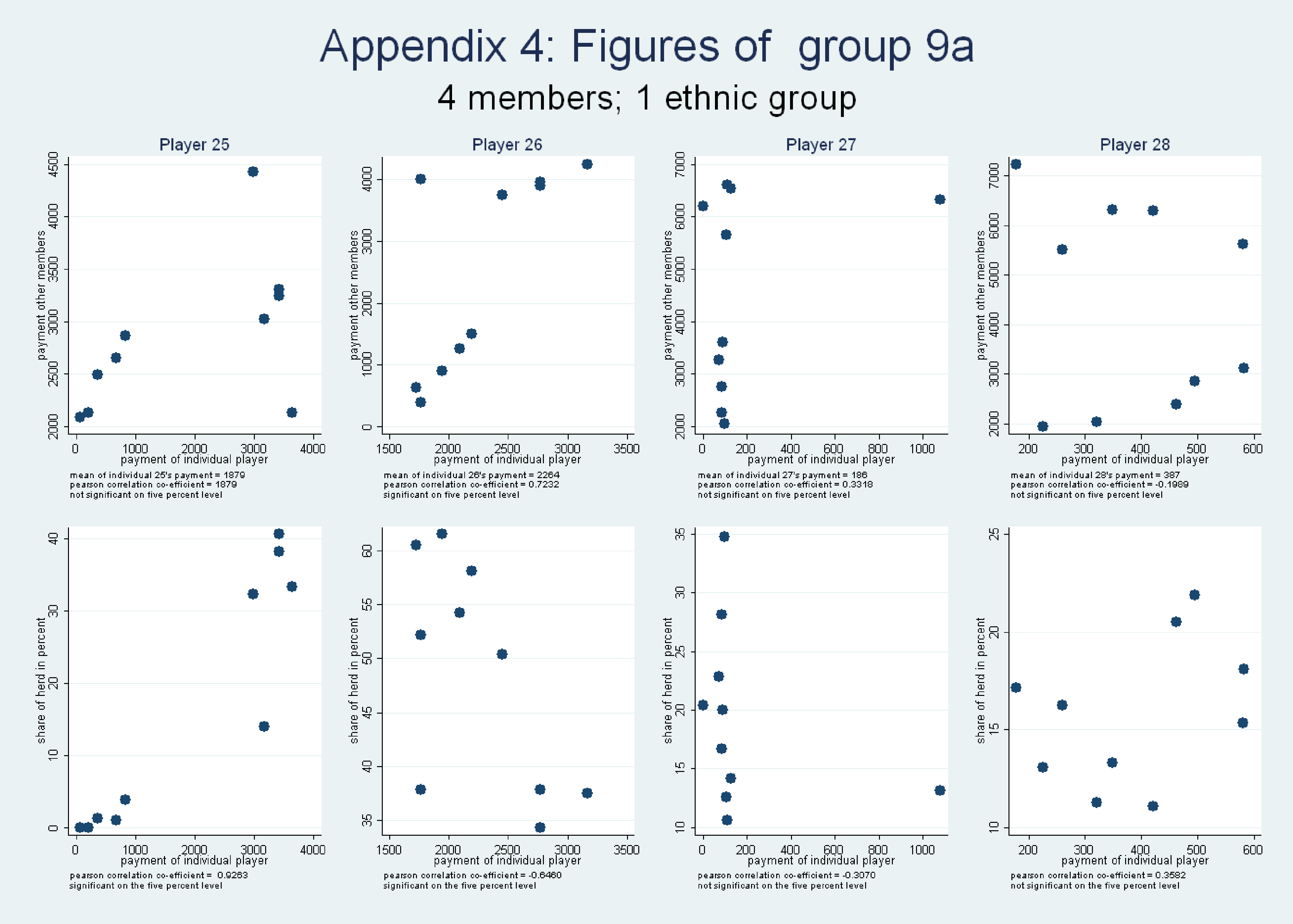
Appendix 4: Figures of group 8a

5 members; 3 ethnic group



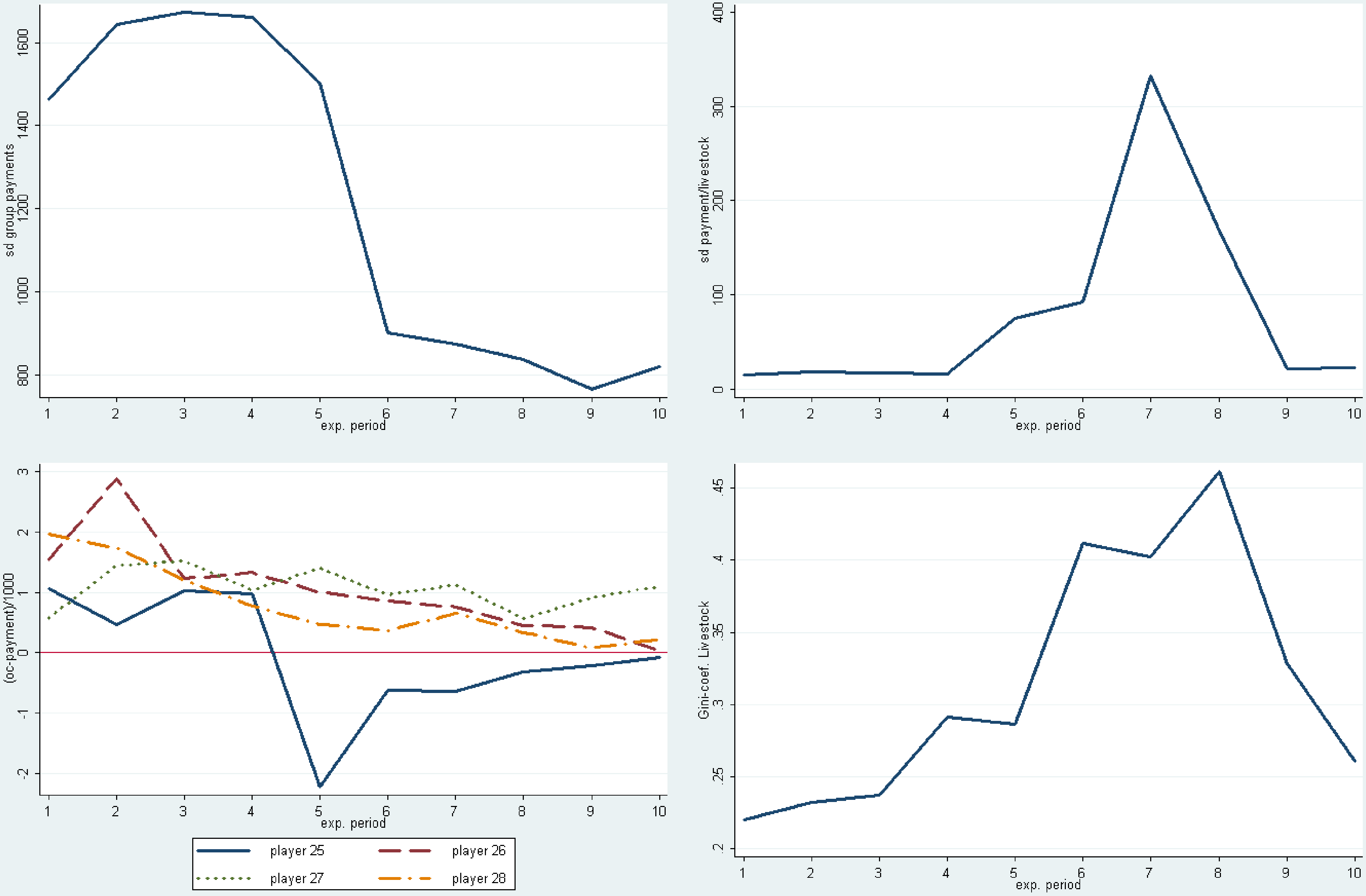
Appendix 4: Figures of group 8b





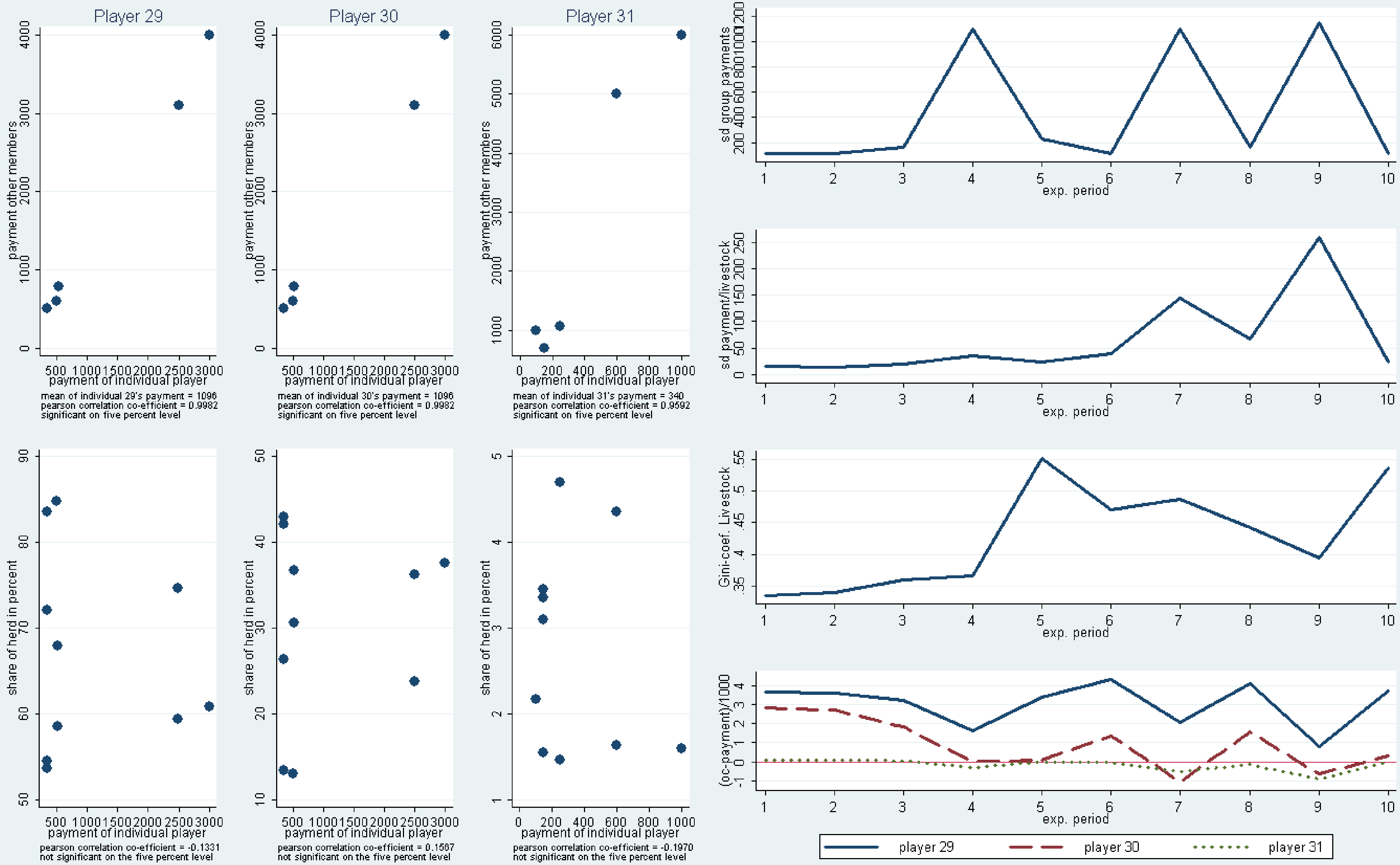
Appendix 4: Figures of group 9a
4 members; 1 ethnic group
Player 25
Player 26
Player 27
Player 28
payment other members
payment of individual player
mean of individual 25's payment = 1879
pearson correlation co-efficient = 1879
not significant on five percent level
mean of individual 26's payment = 2264
pearson correlation co-efficient = 0.7232
significant on five percent level
mean of individual 27's payment = 186
pearson correlation co-efficient = 0.3318
not significant on five percent level
mean of individual 28's payment = 387
pearson correlation co-efficient = -0.1989
not significant on five percent level
share of herd in percent
pearson correlation co-efficient = 0.9263
significant on the five percent level
pearson correlation co-efficient = -0.6460
significant on the five percent level
pearson correlation co-efficient = -0.3070
not significant on the five percent level
pearson correlation co-efficient = 0.3582
not significant on the five percent level

Appendix 4: Figures of group 9b



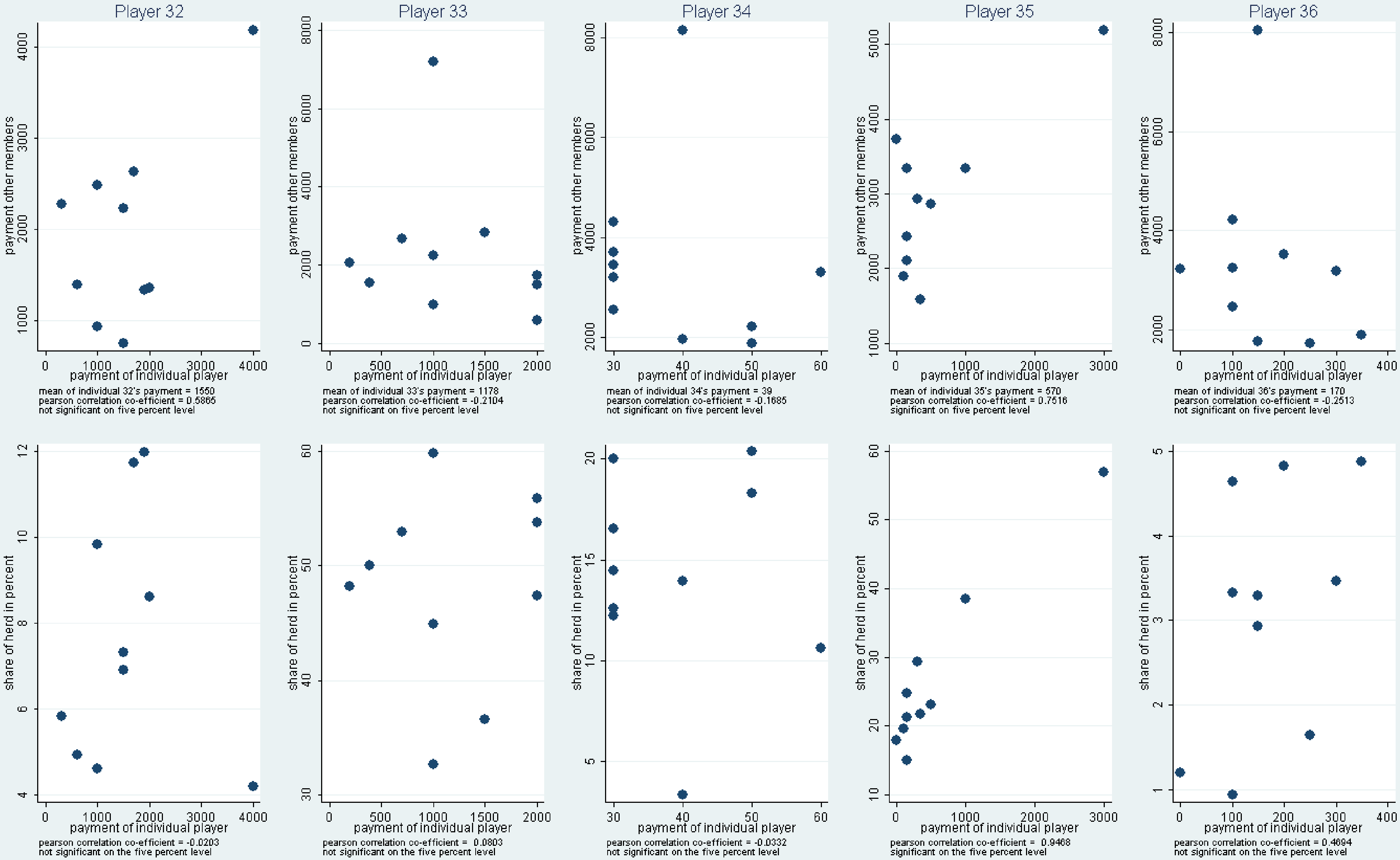
Appendix 4: Figures of group 10

3 members; 2 ethnic group

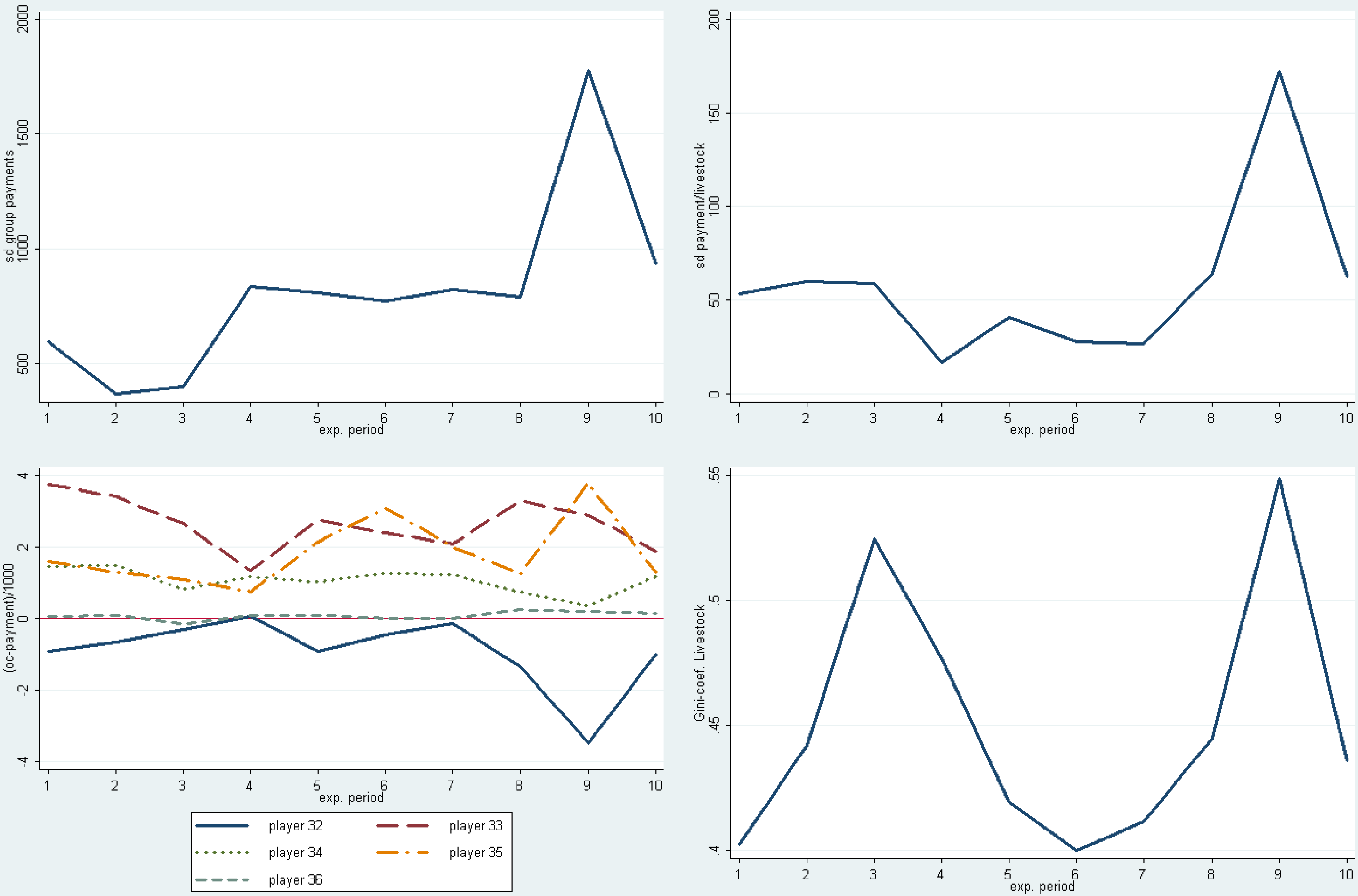


Appendix 4: Figures of group 11a

5 members; 3 ethnic group

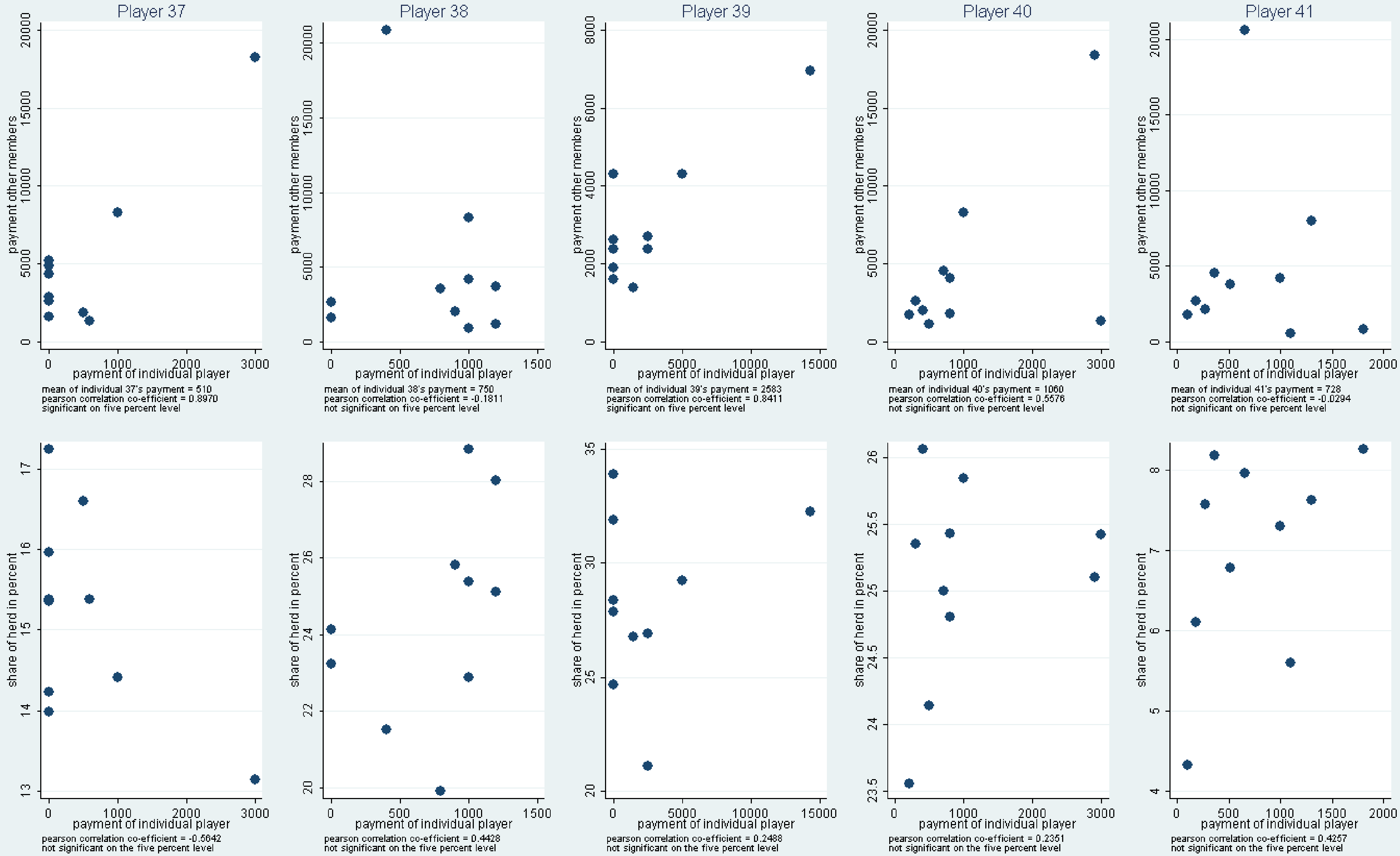


Appendix 4: Figures of group 11b

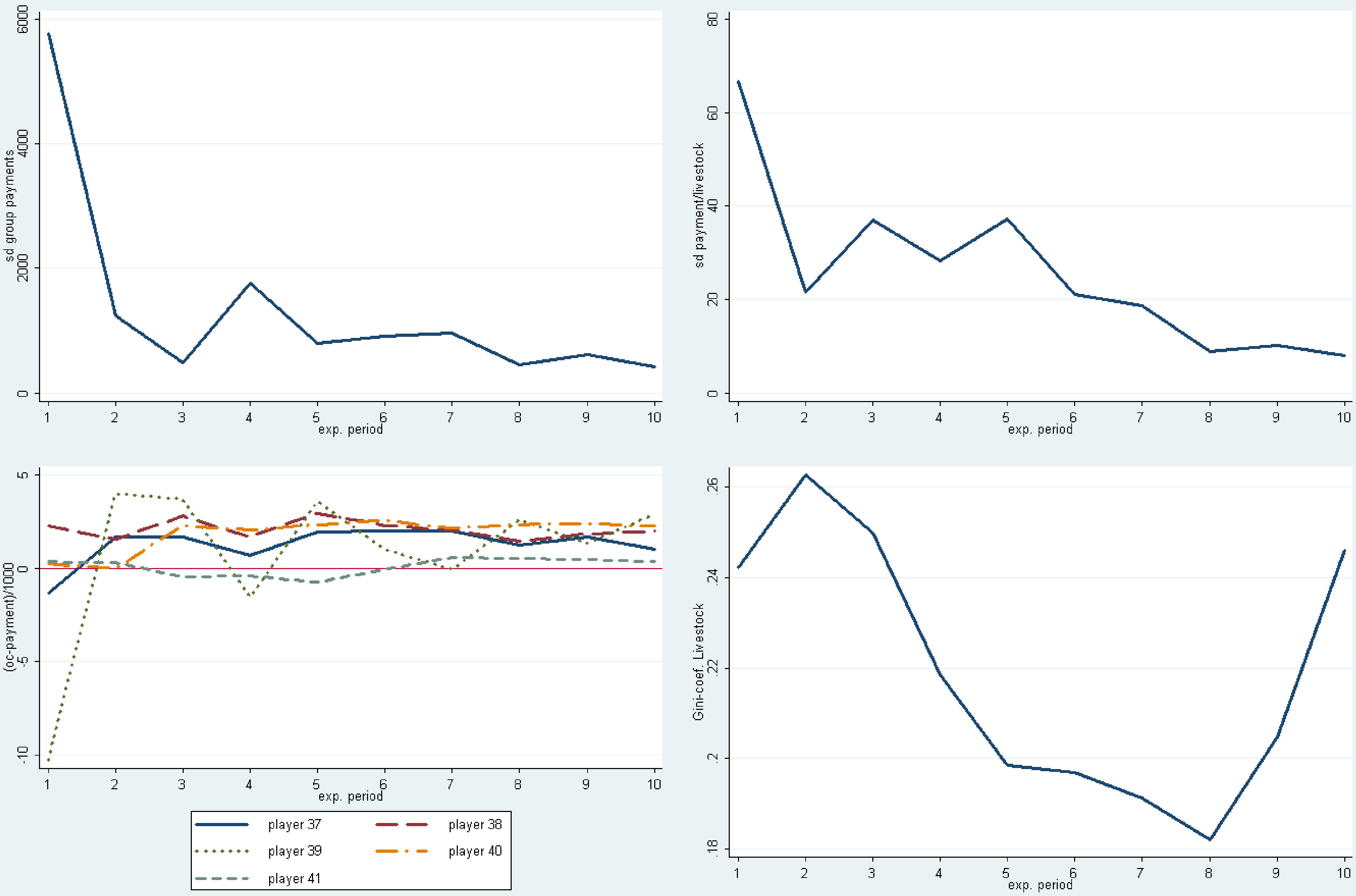


Appendix 4: Figures of group 12a

5 members; 3 ethnic group

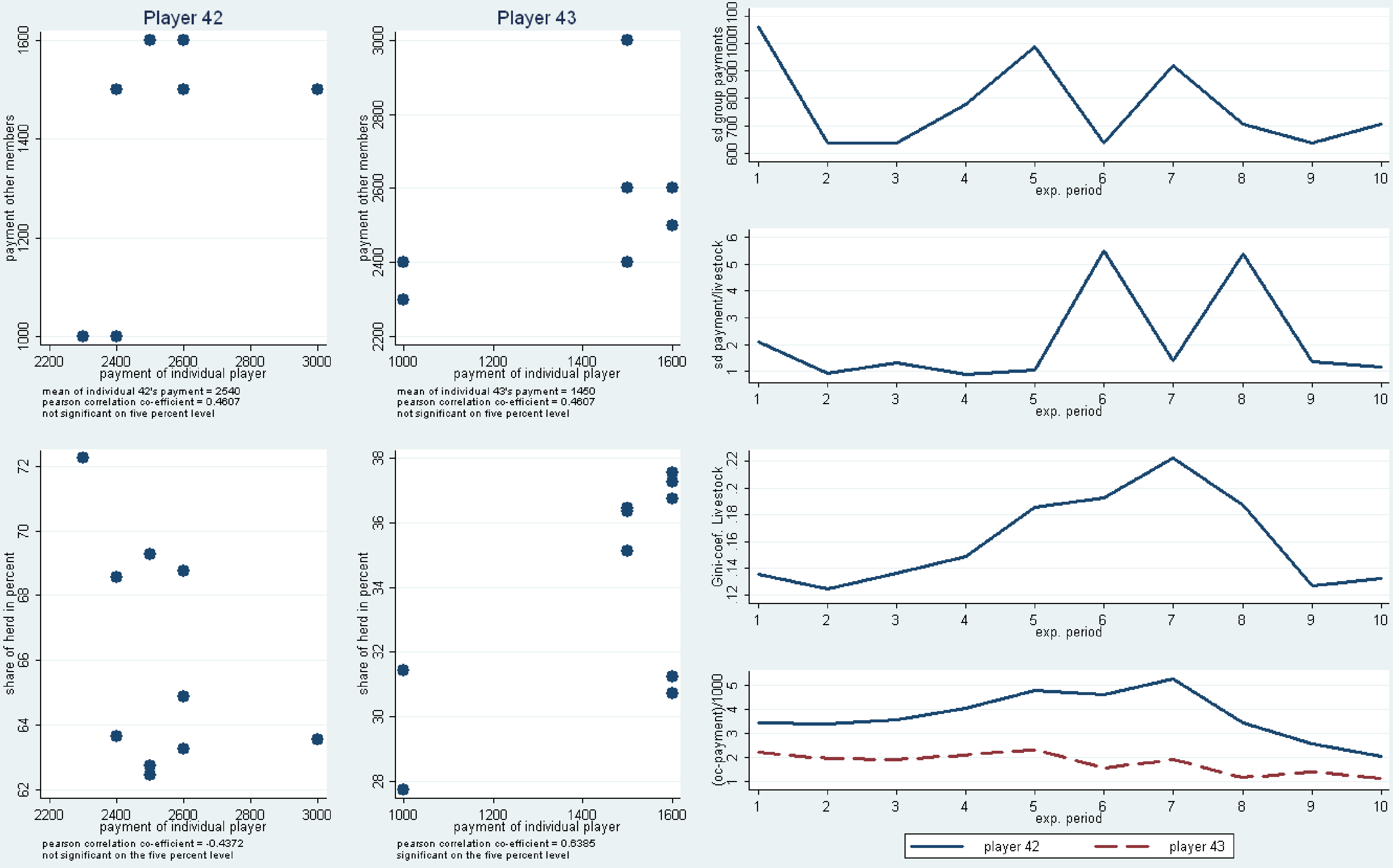


Appendix 4: Figures of group 12b



Appendix 4: Figures of group 13

2 members; 2 ethnic group



Appendix 4: Figures of group 14

2 members; 1 ethnic group