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Social welfare versus inequality aversion in an incomplete contract experiment

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Abstract

We explore experimentally how power asymmetries between partners affect relationship-specific investments. We find that on average players' investments are larger than equilibrium investments.

In contrast to social dilemma experiments, in our experiment preferences for social welfare and those for equality call for different actions. Surprisingly, even disadvantaged players care more for social welfare and less for equality. As a result social welfare increases but so does inequality.

We then study conditions under which power-advantaged players give up power. Power-sharing can be successful in the experiment, even when it is not in a selfish world.

Keywords: Experiments, Incomplete Contracts, Relationship-Specific Investment, Allocation of Power, Social Preferences.

JEL Classification: C91, D23, D86.

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1 Introduction

An essential characteristic of a successful partnership is that all parties involved have an incentive to make significant relationship-specific investments. However, it is not uncommon that one partner has more power than another and is therefore able to appropriate a large share of the overall benefits that accrue from the partnership. Company-community partnerships in the developing world are a case in point. Brazilian Amazonia, for example, has recently witnessed a dramatic increase in large-scale company-community partnerships, particularly those related to the ‘fair trade’ commercialization of non-timber forest products (Morsello, 2006). Indeed, while initially the commercialization of these products was promoted primarily by non-governmental organizations, corporations such as *The Body Shop* or *Ives Rocher* now dominate the scene, having been encouraged by increased demand for environmentally and socially responsible products (Morsello and Adger, 2006).

Despite the growing importance of company-community partnerships in developing economies, there is still much debate about their pros and cons.¹ The main objection against company-community partnerships is the large power imbalance between the trade partners. One aspect of trade deals between large corporations and communities which has led to such a power imbalance concerns premium prices and single buyers (Corry, 1993; Turner, 1995), which drastically undermine the communities’ negotiating power (Mayers and Vermeulen, 2002). The consequence of this power imbalance is that corporations typically appropriate a larger portion of the overall benefits accruing from company-community partnerships.

The objective of this paper is to investigate experimentally whether power imbalances between trading partners discourage or encourage relationship-specific investment when contracts are incomplete. Since the seminal work of Grossman and Hart (1986) and Hart and Moore (1990), it is well understood that there is a close connection between the allocation of power—as determined by the allocation of private control and

¹Advocates suggest that partnerships with large corporations allow local communities to share economic risks, increase market access, build production capacity and alleviate poverty (Mayers, 2000). Critics argue that large corporations do not take into account special characteristics of local communities, such as systems of collective production, sharing and risk avoidance (Morsello, 2004).

property rights—and the incentives of partners to undertake relationship-specific investments. These original articles inspired a great number of subsequent papers, generating an extensive literature. Several applications have been made, from asset ownership and power in organizations to family economics.² In this paper we build on this literature to consider how the balance of power between trading partners impacts on their investment behavior in an experimental setting. Doing so, we obtain insights about the behavioral motives that enter partners' investment decisions under balanced and imbalanced power structures.

Our experimental setup has the following main features. Two equally productive players simultaneously decide how much to invest into a joint production process. The investments in the production process cannot be specified in an ex-ante contract. The total monetary benefit accruing from the production process is a Cobb-Douglas transformation of the players' respective investments. A sharing rule determines how the total monetary benefit from joint production is split between the two players. Under a symmetric or "balanced-power" partnership structure, each player is entitled to an (almost) equal share of the total monetary benefit. Under an asymmetric or "imbalanced-power" partnership structure, the power-advantaged player receives a substantially larger share of the total monetary benefit than the weak player. Throughout the experiment, we elicit not only players' own investment strategies, but also their beliefs about their partners' investment strategies.

Our experimental design allows us to address two sets of questions. The first set is: How do power imbalances between trading partners affect incentives to make relationship-specific investments? What behavioral motives do we detect when we compare partners' investment behavior under balanced and imbalanced power structures? To get at these questions, we exogenously impose both the (symmetric) balanced-power and the (asymmetric) imbalanced-power partnership structure on the players and examine their investment behavior. As in the modern property rights approach pioneered by Grossman and Hart (1986) and Hart and Moore (1990), no allocation of power induces first best investments, but some allocations are more efficient than others. In particular, since the players are equally pro-

²See, for example, Chiu (1998), De Meza and Lockwood (1998), Rajan and Zingales (1998), Schmidt and Nöldeke (1998), Besley and Ghatak (2001), Rasul (2006) and Rainer (2007).

ductive, in our setup theory predicts that total investments would be lower in the presence of power imbalances. This is confirmed by our experimental evidence. However, we also observe behavioral motives entering the players' investment behavior. An interesting feature of our design is that it allows us to clearly disentangle inequality aversion (Fehr and Schmidt, 1999) and social-welfare concerns (Charness and Rabin, 2002). Differently from numerous other experiments in which a Pareto-improvement also decreases inequality, in our case the only way inequality averse players can lower payoff difference is by investing less efficiently. On the other hand, if players are concerned about social-welfare they will raise their investment. One main finding from our experiment can be summarized as follows: When power is shared equally both players invest strictly more than the principle of own-payoff maximization would suggest. Also under the imbalanced-power structure, both types of players invest more than predicted by Nash equilibrium, although overinvestment is higher among strong players. This behavior is consistent with the hypothesis that individuals are concerned with social efficiency (Charness and Rabin, 2002), while it cannot be explained by inequality aversion (Fehr and Schmidt, 1999).

Having established this, we turn our attention to the following question: Under what conditions would a player which is advantaged by an asymmetric sharing rule agree to "tie her hands" and sign a contract that establishes symmetric sharing? For example, in a company-community deal in a developing country, a large corporation may have to decide whether to agree to contracts and mechanisms that allow fairer negotiations between the trade partners (Morsello, 2006). To address this issue, the following experimental procedure is adopted. Players first invest into joint production under both the symmetric and asymmetric sharing rule. Then, after having gained some experience, the players are allowed to switch from an asymmetric rule to a symmetric one. This switch requires mutual consent. Theory predicts that the disadvantaged player always has an incentive to switch to more symmetric rules.³ For the advantaged player the situation is less clear: Switching to a symmetric rule generates better incentives for total investment but also reduces this player's share of the joint profit. We analyze two situations, one in which it is individually rational for strong players to switch to a more equal structure, and one in which they should theo-

³This is because both total investments and weak players' shares of the benefits would increase as a result.

retically refuse to do so. Our key results are the following. Disadvantaged players almost always vote for a balanced-power partnership structure, as one would probably expect. What is more intriguing is the behavior of advantaged players, which exhibits a substantial degree of heterogeneity. On one side, a majority of strong players are willing to give up their strong position irrespective of whether it is individually rational or not. However, there are also participants who are disinclined to abandon power even when the principle of own-payoff maximization tells them to do so.

The remainder of the paper is organized as follows. Section 2 discusses the related experimental literature. Section 3 describes the experimental features and setup. Section 4 generates behavioral prediction. Section 5 presents the results. Section 6 concludes

2 Related Experiments

Despite the mounting evidence that economic agents exhibit social preferences (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Charness and Rabin, 2002), scholars have only recently started to focus on the analysis and implications of the incomplete contract approach when the neoclassical self-interest paradigm does not hold (Hart, 2008; Hart and Moore, 2008). Furthermore there is virtually no experimental evidence testing the predictions of this kind of models.

One notable exception and the closest antecedent to this paper is Fehr et al. (2008b) who use experiments to compare different allocations of ownership rights.⁴ The key finding of this study, which contrasts with the theoretical prediction of the property rights model developed by Hart (1995), is that joint ownership is the most efficient ownership structure. The superiority of joint ownership in the experimental setting can be explained by the fact that it makes better use of fairness as an enforcement device than alternative ownership structures. Our paper looks at the extent to which power imbalances between trade partners affect relationship-specific investments. Although some of the issues we are interested in are similar to those explored in Fehr et al. (2008b), our experimental setup differs markedly from theirs.

⁴Another exception is the study by Fehr et al. (2008a) which provides experimental evidence in line with the idea of Hart and Moore (2008) that competitively determined contracts constitute a reference point for trading relationships.

First, we employ a non-linear payoff function instead of a linear one. Players receive payoffs based on a Cobb-Douglas transformation of their investments into a physical asset. Investments are therefore complements at the margin, and the equilibrium outcome is interior rather than on the boundary of the strategy space. Second, in our experiment players invest simultaneously while Fehr et al. (2008b) look at the case of sequential investments. Due to the simultaneous-move design, the only asymmetry between players is due to the asymmetric sharing rule. Hence, we minimize confounding behavioral effects such as trust or reciprocity. Third, we designed experiments which not only provide insights about the players' investment strategies, but also about the players' beliefs about their opponents' investment strategies. This allows us to identify whether players' actual investment behavior is driven by self-interest, altruism or spite

Our paper also makes contact with several other strands of the experimental literature. Both our study and that by Fehr et al. (2008b) has been preceded by a small experimental literature on hold-up problems. A hold-up problem arises when part of the return on an agent's relationship-specific investment is expropriated by his trading partner in an ex-post process of negotiation. In an early experiment, Hackett (1994) showed that agents who invest relatively more tend to receive larger shares of ex-post surplus. The fact that higher ex-ante investments are rewarded through more favorable ex-post sharing agreements mitigates problems of underinvestment and hold-up, a finding which is also at the heart of the study by Oosterbeek et al. (2003). Gantner et al. (2001) study simple bargaining games with prior production. Their key finding is a significant correlation between a player's input into the production process and the output share she claims during the bargaining process, which suggests that equity considerations matter in this context.

Our experiment also shares some features with the public good game studied by Cason et al. (2004), which looks at what happens if players are allowed to commit to contribute nothing before choosing contributions to a public good. Public good games have been extensively explored in the laboratory. A common finding is that people cooperate more than in the Nash equilibrium, however, cooperation decays during the experiment. The final part of our experiment also bears some aspects of a gift-exchange game. Fehr et al. (1998) find that, although not being a subgame perfect equilibrium, gift exchange actually works in the laboratory.

Table 1 List of experimental treatments

Configuration	SYM	ASYM	FLEX	n
<i>conflict</i> (-C)	SYM-C	ASYM-C	FLEX-C, choice between	8 sessions
$\vartheta = 24.83, \alpha = 0.359$	$\pi = 0.491$	$\pi = 0.708$	$\pi = 0.491$ and $\pi = 0.708$	70 participants
<i>no conflict</i> (-NC)	SYM-NC	ASYM-NC	FLEX-NC, choice between	8 sessions
$\vartheta = 14, \alpha = 0.41$	$\pi = 0.483$	$\pi = 0.748$	$\pi = 0.483$ and $\pi = 0.748$	76 participants

3 Implementation of the Experiment

3.1 Baseline Game and Experimental Design

Consider the following model. There are two agents, A and B . Each agent $i \in \{A, B\}$ owns M_i units of initial endowment of a private good. Each agent chooses how to split M_i between her own consumption (x_i) and investment in a production process (I_i). The monetary value of the output produced by the investments of A and B is given by $Q(I_A, I_B) = \vartheta I_A^\alpha I_B^\beta$, where $\vartheta > 0$, $\alpha > 0$ and $\beta > 0$ are productivity parameters. A sharing rule (or an allocation of power) determines how the monetary value of output is split between the agents. Let $\pi_A = \pi$ be the share that goes to A , and let $\pi_B = 1 - \pi$ be the share that goes to B . Each agent i maximizes a payoff function of the form $U_i(I_A, I_B) = x_i + \pi_i Q(I_A, I_B)$ subject to the constraint $M_i = x_i + I_i$. Throughout the paper, we focus on environments in which the two agents are symmetric in productive terms, i.e. $\alpha = \beta$. For simplicity of notation, we will only refer to α hereafter.

We report data from an experiment based on the above basic model. The experiment was run at the University of Jena (Germany) in June and July 2008 and was computerized using z-Tree (Fischbacher, 2007). A total of 146 participants, recruited with Orsee (Greiner, 2004), and took part in the experiment. A translation of the instructions can be found in appendix B. Table 1 is useful in explaining the general structure of the experiment. Participants were assigned to one of our two treatments: *conflict* and *no conflict*. Within a treatment, participants experience three types of contracts: an *asymmetric contract* (ASYM), a *symmetric contract* (SYM) and a *flexible contract* (FLEX). In ASYM and SYM, the sharing rule used to divide the benefits from joint production is exogenously fixed. We will refer to these two treatments as *fixed contracts*. SYM and ASYM represent exemplifications of situations characterized by power balance and

imbalance respectively. In FLEX participants can choose either a symmetric or an asymmetric contract. If, in FLEX, both participants chose the same sharing rule then this rule was adopted. In case of disagreement the asymmetric rule ASYM is used as the default rule. The FLEX treatment allows to analyze whether participants want to switch from an asymmetric to a symmetric power structure.

At the beginning of each session we decided randomly whether we would first play 10 rounds of ASYM (this happened in 7 sessions) and then 10 rounds of SYM, or whether to use the opposite sequence (this happened in 9 sessions). After the experience with both SYM and ASYM fixed contract treatments participants played 10 rounds of FLEX.⁵ Participants were re-matched randomly after each round. Though different parameters (ϑ and α) and sharing rules are employed in *conflict* and *no conflict*, equilibrium predictions for the two configurations differ mainly in the flexible contract treatment. With the *conflict*-parameters there is a conflict of interest between the two players: in FLEX-C the selfish *A*-players prefer the asymmetric contract while *B*-players prefer the symmetric contract. With the *no conflict*-parameters this is not the case: in FLEX-NC both types of players, *A* and *B*, prefer the symmetric contract. We will explain this more precisely when illustrating this treatment. When discussing asymmetric contracts, we will refer to type *A* players as strong and to type *B* players as weak. We now turn to a more detailed description of the experiment.

3.2 Fixed Contracts

In ASYM and SYM, we elicit data on players' investment behavior when the sharing rule is exogenous. In each treatment, players simultaneously invest into joint production under either symmetric or asymmetric sharing rules. Under symmetric sharing rules (π^{SYM} is 0.491 or 0.483), each player is entitled to an *almost equal* share of the total monetary output. Under asymmetric sharing rules (π^{ASYM} is 0.708 or 0.748), the strong player receives a substantially larger portion of the total output. In our experiment, players choose integer investment numbers only (multiples of 50 from 0 to 500) and derive their payoffs from payoff tables. The parameter values (ϑ and α) used in our treatments are given in Table 1. Together

⁵In one session of the experiment we played 12 and not 10 rounds of each contract.

Table 2 Payoffs in ASYM-C

		$\pi = 0.708, \vartheta = 24.83, \alpha = 0.359$										
		player B										
		0	50	100	150	200	250	300	350	400	450	500
		+500 500	450 500	400 500	350 500	300 500	250 500	200 500	150 500	100 500	50 500	0 500
player A	0											
	50	500 450	570 742	554 824	528 883	498 930	464 970	429 1005	392 1036	354 1065	315 1092	275 1117
	100	500 400	604 774	598 880	579 955	554 1015	525 1067	494 1112	460 1152	425 1189	390 1223	353 1255
	150	500 350	628 783	629 905	615 992	594 1062	568 1121	540 1173	509 1220	476 1263	443 1302	408 1339
	200	500 300	648 780	654 915	644 1012	625 1089	603 1155	576 1213	548 1265	517 1312	485 1356	452 1397
	250	500 250	664 770	675 917	668 1021	653 1105	632 1176	608 1239	581 1295	552 1347	522 1394	490 1438
	300	500 200	679 755	694 912	690 1023	676 1113	658 1189	635 1256	610 1316	583 1371	554 1421	523 1468
	350	500 150	692 736	710 902	709 1020	698 1115	681 1195	660 1266	636 1329	610 1387	582 1441	553 1490
	400	500 100	704 715	725 889	726 1013	717 1112	702 1197	683 1271	660 1337	635 1398	608 1454	580 1506
	450	500 50	715 692	740 873	743 1002	735 1106	722 1194	704 1271	682 1341	658 1404	633 1463	605 1517
	500	500 0	725 667	753 855	758 989	752 1097	740 1188	723 1268	703 1340	680 1406	655 1467	628 1524

with $M_i = 500$, $i \in \{A, B\}$, we obtain the payoff matrices given in Tables 2 to 5. Payoffs are rounded to integers. For the convenience of the reader, the tables show best replies and Nash equilibria, although players were not provided this information and used plain payoff tables. Finally, in the experiment the values of the investments (0 to 500) are replaced by consecutive numbers (1 to 11).

Discretizing a continuous problem and presenting it with the help of payoff tables has both advantages and disadvantages. A key advantage is that it allows us to elicit players' expectations in a natural way. In each round of the experiment, players are asked to click on a row they might want to choose and on a column they think their opponents might select. These rows and columns and their intersection are then highlighted on the computer screen. Participants can experiment by clicking on rows and columns as often as they want until they are satisfied with their choices and expectations. Only when a participant clicks on an "OK" button does she proceed to the result stage of the round. This design feature not only allows us to check for the consistency of players' expectations and behavior, but it also promotes a more thoughtful decision-making process.

The disadvantage of discretizing a continuous problem is that it quickly leads to a large number of equilibria. If we want to have a clear equilibrium

Table 3 Payoffs in SYM-C

$\pi = 0.491, \vartheta = 24.83, \alpha = 0.359$							player B					
	0	50	100	150	200	250	300	350	400	450	500	
player A	0	<div>+500 500</div>	<div>450 500</div>	<div>400 500</div>	<div>350 500</div>	<div>300 500</div>	<div>250 500</div>	<div>200 500</div>	<div>150 500</div>	<div>100 500</div>	<div>50 500</div>	<div>0 500</div>
	50	<div>500 450</div>	<div>660 652</div>	<div>669 709</div>	<div>661 750</div>	<div>645 783</div>	<div>624 810</div>	<div>599 835</div>	<div>572 857</div>	<div>542 877</div>	<div>511 895</div>	<div>479 912</div>
	100	<div>500 400</div>	<div>719 659</div>	<div>745 733</div>	<div>749 785</div>	<div>742 827</div>	<div>729 862</div>	<div>712 894</div>	<div>691 922</div>	<div>667 947</div>	<div>642 971</div>	<div>615 993</div>
	150	<div>500 350</div>	<div>761 650</div>	<div>799 735</div>	<div>811 795</div>	<div>812 844</div>	<div>804 885</div>	<div>792 921</div>	<div>776 953</div>	<div>756 983</div>	<div>735 1010</div>	<div>711 1036</div>
	200	<div>500 300</div>	<div>795 633</div>	<div>842 727</div>	<div>862 794</div>	<div>+867 847</div>	<div>865 893</div>	<div>856 933</div>	<div>844 969</div>	<div>828 1002</div>	<div>809 1032</div>	<div>788 1060</div>
	250	<div>500 250</div>	<div>824 610</div>	<div>879 712</div>	<div>904 785</div>	<div>915 843</div>	<div>916 892</div>	<div>911 936</div>	<div>901 975</div>	<div>888 1010</div>	<div>872 1043</div>	<div>854 1074</div>
	300	<div>500 200</div>	<div>849 585</div>	<div>912 694</div>	<div>942 771</div>	<div>956 833</div>	<div>961 886</div>	<div>959 932</div>	<div>952 974</div>	<div>942 1012</div>	<div>928 1047</div>	<div>912 1080</div>
	350	<div>500 150</div>	<div>872 557</div>	<div>941 672</div>	<div>976 753</div>	<div>994 819</div>	<div>1001 875</div>	<div>1002 924</div>	<div>998 968</div>	<div>990 1008</div>	<div>978 1045</div>	<div>964 1080</div>
	400	<div>500 100</div>	<div>892 527</div>	<div>967 647</div>	<div>1006 733</div>	<div>1028 802</div>	<div>1038 860</div>	<div>1042 912</div>	<div>1040 958</div>	<div>1033 1000</div>	<div>1024 1039</div>	<div>1011 1075</div>
	450	<div>500 50</div>	<div>911 495</div>	<div>992 621</div>	<div>1035 710</div>	<div>1059 782</div>	<div>1072 843</div>	<div>1078 897</div>	<div>1078 945</div>	<div>1074 989</div>	<div>1066 1030</div>	<div>1055 1067</div>
	500	<div>500 0</div>	<div>929 462</div>	<div>1015 593</div>	<div>1061 686</div>	<div>1088 760</div>	<div>1104 824</div>	<div>1112 880</div>	<div>1114 930</div>	<div>1111 975</div>	<div>1105 1017</div>	<div>1095 1057</div>

Table 4 Payoffs in ASYM-NC

$\pi = 0.748, \vartheta = 14, \alpha = 0.41$												
		player B										
		0	50	100	150	200	250	300	350	400	450	500
player A	0	<div><div>+500</div><div>500</div></div>	<div><div>450</div><div>500</div></div>	<div><div>400</div><div>500</div></div>	<div><div>350</div><div>500</div></div>	<div><div>300</div><div>500</div></div>	<div><div>250</div><div>500</div></div>	<div><div>200</div><div>500</div></div>	<div><div>150</div><div>500</div></div>	<div><div>100</div><div>500</div></div>	<div><div>50</div><div>500</div></div>	<div><div>0</div><div>500</div></div>
	50	<div><div>500</div><div>450</div></div>	<div><div>537</div><div>709</div></div>	<div><div>516</div><div>794</div></div>	<div><div>487</div><div>856</div></div>	<div><div>454</div><div>907</div></div>	<div><div>419</div><div>951</div></div>	<div><div>382</div><div>990</div></div>	<div><div>344</div><div>1025</div></div>	<div><div>305</div><div>1057</div></div>	<div><div>265</div><div>1087</div></div>	<div><div>224</div><div>1116</div></div>
	100	<div><div>500</div><div>400</div></div>	<div><div>566</div><div>744</div></div>	<div><div>554</div><div>857</div></div>	<div><div>532</div><div>940</div></div>	<div><div>505</div><div>1007</div></div>	<div><div>474</div><div>1066</div></div>	<div><div>442</div><div>1117</div></div>	<div><div>407</div><div>1164</div></div>	<div><div>372</div><div>1207</div></div>	<div><div>335</div><div>1247</div></div>	<div><div>298</div><div>1284</div></div>
	150	<div><div>500</div><div>350</div></div>	<div><div>587</div><div>756</div></div>	<div><div>582</div><div>890</div></div>	<div><div>565</div><div>987</div></div>	<div><div>542</div><div>1067</div></div>	<div><div>515</div><div>1136</div></div>	<div><div>485</div><div>1197</div></div>	<div><div>454</div><div>1252</div></div>	<div><div>421</div><div>1303</div></div>	<div><div>387</div><div>1350</div></div>	<div><div>352</div><div>1394</div></div>
	200	<div><div>500</div><div>300</div></div>	<div><div>604</div><div>757</div></div>	<div><div>605</div><div>907</div></div>	<div><div>592</div><div>1017</div></div>	<div><div>572</div><div>1107</div></div>	<div><div>548</div><div>1184</div></div>	<div><div>521</div><div>1253</div></div>	<div><div>492</div><div>1315</div></div>	<div><div>461</div><div>1372</div></div>	<div><div>429</div><div>1425</div></div>	<div><div>396</div><div>1475</div></div>
	250	<div><div>500</div><div>250</div></div>	<div><div>619</div><div>751</div></div>	<div><div>624</div><div>916</div></div>	<div><div>615</div><div>1036</div></div>	<div><div>598</div><div>1134</div></div>	<div><div>576</div><div>1219</div></div>	<div><div>552</div><div>1294</div></div>	<div><div>525</div><div>1362</div></div>	<div><div>496</div><div>1425</div></div>	<div><div>465</div><div>1483</div></div>	<div><div>434</div><div>1538</div></div>
	300	<div><div>500</div><div>200</div></div>	<div><div>632</div><div>740</div></div>	<div><div>+642</div><div>917</div></div>	<div><div>635</div><div>1047</div></div>	<div><div>621</div><div>1153</div></div>	<div><div>602</div><div>1244</div></div>	<div><div>579</div><div>1325</div></div>	<div><div>554</div><div>1399</div></div>	<div><div>527</div><div>1466</div></div>	<div><div>498</div><div>1529</div></div>	<div><div>467</div><div>1587</div></div>
	350	<div><div>500</div><div>150</div></div>	<div><div>644</div><div>725</div></div>	<div><div>657</div><div>914</div></div>	<div><div>654</div><div>1052</div></div>	<div><div>642</div><div>1165</div></div>	<div><div>625</div><div>1262</div></div>	<div><div>604</div><div>1349</div></div>	<div><div>580</div><div>1427</div></div>	<div><div>554</div><div>1499</div></div>	<div><div>527</div><div>1566</div></div>	<div><div>498</div><div>1628</div></div>
	400	<div><div>500</div><div>100</div></div>	<div><div>655</div><div>707</div></div>	<div><div>672</div><div>907</div></div>	<div><div>671</div><div>1053</div></div>	<div><div>661</div><div>1172</div></div>	<div><div>646</div><div>1275</div></div>	<div><div>627</div><div>1366</div></div>	<div><div>604</div><div>1449</div></div>	<div><div>580</div><div>1525</div></div>	<div><div>554</div><div>1595</div></div>	<div><div>526</div><div>1661</div></div>
	450	<div><div>500</div><div>50</div></div>	<div><div>665</div><div>687</div></div>	<div><div>685</div><div>897</div></div>	<div><div>687</div><div>1050</div></div>	<div><div>679</div><div>1175</div></div>	<div><div>665</div><div>1283</div></div>	<div><div>648</div><div>1379</div></div>	<div><div>627</div><div>1466</div></div>	<div><div>604</div><div>1545</div></div>	<div><div>579</div><div>1619</div></div>	<div><div>552</div><div>1688</div></div>
	500	<div><div>500</div><div>0</div></div>	<div><div>674</div><div>666</div></div>	<div><div>698</div><div>884</div></div>	<div><div>702</div><div>1044</div></div>	<div><div>696</div><div>1175</div></div>	<div><div>684</div><div>1288</div></div>	<div><div>667</div><div>1387</div></div>	<div><div>648</div><div>1478</div></div>	<div><div>626</div><div>1561</div></div>	<div><div>602</div><div>1638</div></div>	<div><div>576</div><div>1711</div></div>

Table 5 Payoffs in SYM-NC

		$\pi = 0.483, \vartheta = 14, \alpha = 0.41$										
		player B										
		0	50	100	150	200	250	300	350	400	450	500
player A	0	+500 500	450 500	400 500	350 500	300 500	250 500	200 500	150 500	100 500	50 500	0 500
	50	500 450	629 617	638 672	631 712	616 745	596 773	573 799	547 821	520 842	491 862	460 880
	100	500 400	688 622	716 695	723 749	720 792	710 830	696 863	678 893	658 921	635 947	611 971
	150	500 350	731 612	773 699	791 762	796 813	793 857	785 897	774 933	759 965	741 996	722 1024
	200	500 300	766 595	820 692	846 763	858 821	861 871	859 915	852 955	841 992	828 1027	812 1059
	250	500 250	796 573	860 680	893 757	911 821	920 876	922 924	919 968	912 1009	902 1046	890 1081
	300	500 200	823 549	896 663	935 747	959 815	972 874	978 927	979 974	975 1018	968 1058	959 1096
	350	500 150	847 521	928 643	974 733	1002 805	1019 868	1029 924	+1033 975	1032 1021	1028 1064	1022 1104
	400	500 100	870 492	958 621	1009 715	1041 792	1062 859	1075 918	1082 971	1085 1020	1083 1065	1079 1108
	450	500 50	891 462	985 597	1041 696	1078 777	1102 846	1118 908	1128 964	1133 1015	1135 1063	1132 1108
	500	500 0	910 430	1011 571	1072 674	1112 759	1140 831	1159 896	1172 954	1179 1008	1182 1058	1182 1105

prediction, and still present payoffs in the form of tables, then we have to live with a parameter space that is considerably restricted. In particular, we can only use values of π which are bounded away from $1/2$. Hence, when we call a sharing rule “symmetric” then this is only an approximation; $\pi = 0.491$ and $\pi = 0.483$ are as close as we can get to $1/2$.

We illustrate the best reply functions for ASYM and SYM, under either *conflict* or *no conflict*, in Figures 1 and 2, assuming that individuals are motivated purely by self-interest. For each situation there is an interior Nash equilibrium in which both players invest part of their endowment into joint production; there also is an equilibrium in which both players invest zero. We note that no sharing rule induces first best investments. Intuitively, this is because players do not capture the full marginal returns on their investments. As a consequence, equilibrium investment levels are inefficiently low. However, some sharing rules provide better investment incentives than others. In particular, if participants in the experiment are motivated by self-interest *and* select interior equilibria, then asymmetric sharing rules lead to lower aggregate investments than symmetric sharing rules.⁶

⁶Theoretically, if players simultaneously choose I_A and I_B to respectively maximize

Figure 1 Best reply functions in SYM-C and ASYM-C with *conflict*

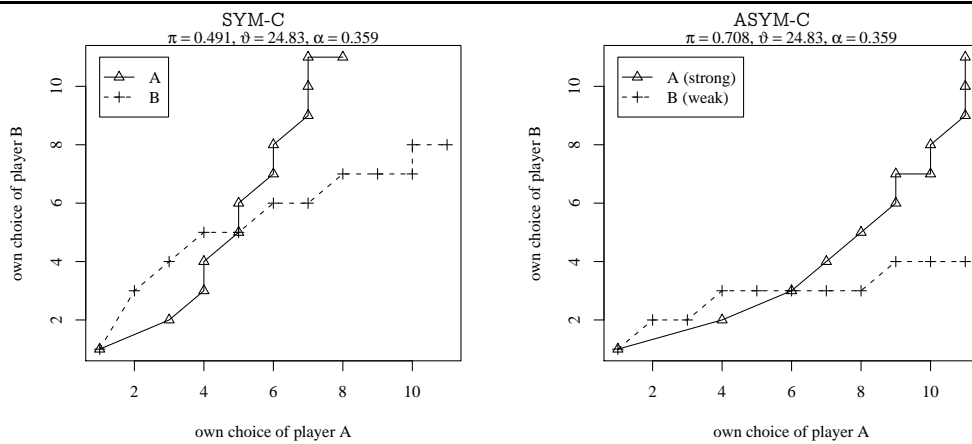


Figure 2 Best reply functions in SYM-NC and ASYM-NC with *no conflict*

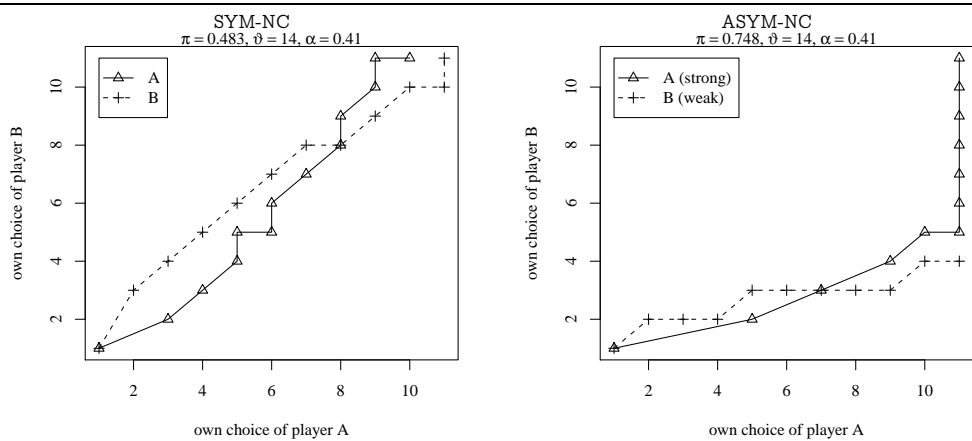
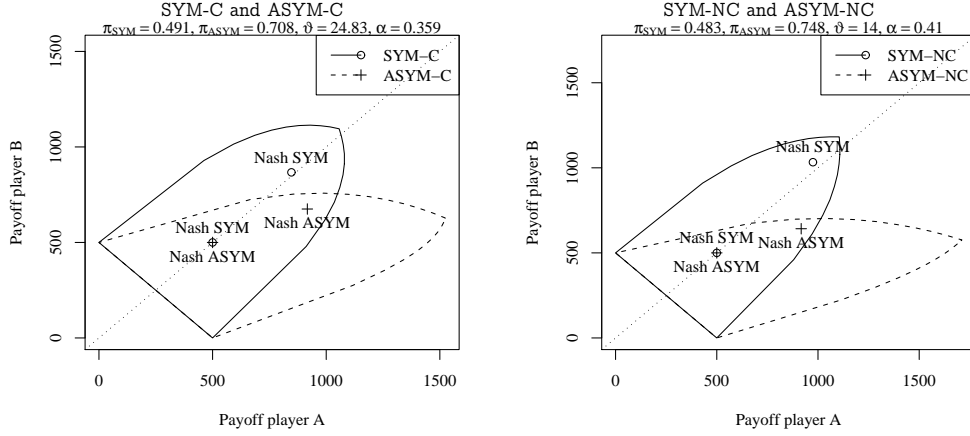


Figure 3 Convex hull of payoff possibilities

We now turn our attention to payoff distributions. If players follow standard equilibrium predictions and select interior equilibria, then asymmetric sharing rules not only imply lower aggregate investments, but also unequal payoff distributions. This is illustrated in Figure 3, which shows the convex hull of the feasible payoff pairs for both treatments, under either *conflict* or *no conflict*. The dashed line marks the set of all payoff combinations that can be obtained with asymmetric sharing rules, while the solid line marks the set of all payoff combinations that can be achieved with symmetric sharing rules. Equilibrium payoff pairs implied by asymmetric sharing rules are marked with a “+”, while those implied by symmetric sharing rules are marked with a “o”. Focusing on payoff pairs associated with interior equilibria, we see that ASYM sharing rules give rise to rather large payoff differences. The interior equilibrium payoffs of type *A* players exceed those of type *B* players by about 36% in *conflict* and 43% in *no conflict*. For the sharing rules that we call SYM there is still a deviation, but is much smaller: 2% in *conflict* and 6% in *no conflict*.

$M_A - I_A + \pi \vartheta I_A^a I_B^b$ and $M_B - I_B + (1 - \pi) \vartheta I_A^a I_B^b$, then the sharing rule that maximizes joint payoffs and provides optimal investment incentives is given by

$$\pi^* = \frac{1}{1 + \varphi} \quad \text{where} \quad \varphi = \sqrt{\frac{(1-a)b}{(1-b)a}}.$$

If players are symmetric in productive terms ($a = b$), then $\varphi = 1$ and the optimal sharing rule is governed by the principle of equal splits.

3.3 Flexible Contracts

After having played the fixed contract game with both symmetric and asymmetric sharing rules, in FLEX players can choose between ASYM and SYM. The default rule is always ASYM. If both players prefer the same contract (either SYM or ASYM), then this contract is implemented; if players disagree, then the status quo contract ASYM is used. We use the strategy method and ask in each period players whether they prefer SYM or ASYM and, simultaneously, which investment they would choose under ASYM and under SYM.

Which contracts should players choose? Observing Figure 3 we notice that in both conditions, *conflict* and *no conflict*, a weak (*B*) player prefers SYM over ASYM in equilibrium. Intuitively, this is because both total investments and the weak player's share increase from ASYM to SYM. For the strong (*A*) player the situation is different: On the one hand, an agreement to implement a more equitable sharing rule reduces a strong (*A*) player's share of the total surplus ("surplus division effect"). On the other hand, such an agreement induces the weak (*B*) player to invest more into joint production ("investment effect"). Under *conflict*, the surplus division effect dominates the investment effect, and so it is rational for a strong (*A*) player to veto the implementation of a more equitable sharing rule. Under *no conflict*, the investment effect dominates the surplus division effect, and hence it is rational for a strong (*A*) player to give up her power in favor of a symmetric sharing rule.

4 Behavioral Predictions

Our discussion and predictions so far are based on the assumption of common knowledge of rationality and selfishness of all players. However, experimental evidence suggests that not all individuals simply maximize monetary payoffs. Two features of our basic model make it conceivable that behavioral motives might enter players' investment decisions. First, if individuals are purely motivated by self-interest, we have seen that equilibrium investment levels are inefficiently low. Players' investment behavior might therefore reflect a *concern for social efficiency*. Second, if players follow standard equilibrium predictions, then asymmetric sharing rules not only imply inefficiently low aggregate investments, but also highly unequal

payoff distributions. Individuals' investment behavior might therefore also be driven by an intrinsic preference to *minimize differences in payoffs*. Furthermore, it is also conceivable that individuals may be motivated by *competitive preferences*, hence caring not only about their own material payoff, but also preferring to do as well as possible compared to their opponent.

To address these issues, we now generate behavioral predictions by modifying individual preferences in a way proposed by Charness and Rabin (2002). While the players in our experiment choose integer investment numbers only, it is instructive to generate behavioral predictions based on the continuous choice problem underlying the experiment. Letting

$$U_A(I_A, I_B) = M - I_A + \pi \vartheta(I_A I_B)^a \quad \text{and} \quad U_B(I_A, I_B) = M - I_B + (1 - \pi) \vartheta(I_A I_B)^a \quad (1)$$

denote player A 's and B 's monetary payoffs as functions of their respective investments, suppose that individuals preferences are given by:

$$V_A(I_A, I_B) = (\rho \cdot r + \sigma \cdot s) \cdot U_B(I_A, I_B) + (1 - \rho \cdot r - \sigma \cdot s) \cdot U_A(I_A, I_B) \quad (2)$$

and

$$V_B(I_A, I_B) = (\rho \cdot s + \sigma \cdot r) \cdot U_A(I_A, I_B) + (1 - \rho \cdot s - \sigma \cdot r) \cdot U_B(I_A, I_B) \quad (3)$$

where $r = 1$ and $s = 0$ if $U_A(\cdot) > U_B(\cdot)$, $r = 0$ and $s = 1$ if $U_A(\cdot) < U_B(\cdot)$, and $r = 0$ and $s = 0$ if $U_A(\cdot) = U_B(\cdot)$. This is basically the model of Charness and Rabin (2002), except that, in this simultaneous move game, we leave out the term for reciprocity. The parameters ρ and σ allow for a range of different “distributional preferences”. We focus here on “competitive preferences”, “difference-averse preferences” and “social-welfare preferences”. Competitive preferences can be represented by assuming that $\sigma \leq \rho \leq 0$, meaning that each player prefers to do as well as possible in comparison to her opponent, while also caring directly about her own payoff. Models of inequity (difference) aversion (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000) assume that people prefer to minimize disparities between their own payoffs and those of other people. Inequity aversion corresponds to $\sigma < -\rho < 0$. That is, people suffer utility losses from both disadvantageous and advantageous payoff disparities, but suffer more from disparities that are to their disadvantage. By contrast, the notion of social-welfare preferences captures the idea that individuals prefer

higher payoffs for themselves and for other persons, but are more concerned about own payoffs when they are disadvantaged compared to others (Charness and Rabin, 2002). Concerns for social-welfare can be represented by assuming that $1 > \rho > \sigma > 0$. We now explain how these three different forms of distributional preferences would theoretically affect players' incentives to invest into joint production.

Suppose that the sharing rule used to divide output is exogenous. As a benchmark, consider the equilibrium investments under the assumption of selfishness of all players. In this case, the investments I_A and I_B are chosen simultaneously and non-cooperatively to maximize $U_A(I_A, I_B)$ and $U_B(I_A, I_B)$, respectively.⁷ We have:

Proposition 1 *If the participants exhibit self-interested preferences ($r = s = 0$), then there exists a unique interior Nash equilibrium in pure strategies in which the participants' investment levels are given by*

$$I_A^s = [\alpha \vartheta \pi^{1-\alpha} (1 - \pi)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad I_B^s = [\alpha \vartheta \pi^\alpha (1 - \pi)^{1-\alpha}]^{\frac{1}{1-2\alpha}} \quad (4)$$

Proof. See appendix A.1.

We next consider how distributional concerns would alter the players' investment incentives. As we will demonstrate below, the equilibrium investments of individuals exhibiting distributional preferences depend on the degree of asymmetry in the sharing rule π . Without loss of generality, we restrict our attention to parameter values satisfying $\pi \geq \frac{1}{2}$, i.e., the case in which any asymmetry in the sharing rule favors player A and discriminates against player B . Opposite points hold for the symmetric counterpart in which $\pi \leq \frac{1}{2}$. For algebraic convenience, define

$$\kappa_A = \frac{(1 - \rho)\pi + \rho(1 - \pi)}{1 - \rho} \quad \text{and} \quad \gamma_B = \frac{(1 - \sigma)(1 - \pi) + \sigma\pi}{1 - \sigma} \quad (5)$$

and

$$\varepsilon = \frac{2\pi - 1}{\alpha}. \quad (6)$$

We have the following:

⁷In the discussion to follow, we will ignore the existence of an equilibrium in which both players invest zero.

Proposition 2 *Suppose the players exhibit distributional preferences ($r \neq 0$ and $s \neq 0$). Assume $\pi \geq \frac{1}{2}$ and define:*

$$\bar{\pi} = \frac{\mu}{1 + \mu} \quad \text{where} \quad \mu = \frac{(1 - \sigma)[(1 - \alpha)(1 - \rho) + \rho\alpha]}{(1 - \rho)[(1 - \alpha)((1 - \sigma) + \sigma\alpha)]} > 1.^8 \quad (7)$$

(a) *If the sharing rule π is sufficiently bounded away from one-half, $\pi \in [\bar{\pi}, 1)$, then there exists a unique interior Nash equilibrium in pure strategies in which the players' investment levels are given by*

$$I_A^* = [\alpha\vartheta(\kappa_A)^{1-\alpha}(\gamma_B)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad I_B^* = [\alpha\vartheta(\kappa_A)^\alpha(\gamma_B)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (8)$$

(b) *If the sharing rule π is sufficiently close to one-half, $\pi \in [\frac{1}{2}, \bar{\pi})$, then there exists a closed set of Pareto-rankable Nash equilibria in pure strategies. In the most efficient equilibrium the players' investment levels are given by*

$$\bar{I}_A = [\alpha\vartheta(\kappa_A)^{1-\alpha}(\kappa_A - \varepsilon)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad \bar{I}_B = [\alpha\vartheta(\kappa_A)^\alpha(\kappa_A - \varepsilon)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (9)$$

In the least efficient equilibrium the players' investment levels are given by

$$\underline{I}_A = [\alpha\vartheta(\gamma_B + \varepsilon)^{1-\alpha}(\gamma_B)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad \underline{I}_B = [\alpha\vartheta(\gamma_B + \varepsilon)^\alpha(\gamma_B)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (10)$$

Proof. See appendix A.2.⁹

If the sharing rule used to divide output is sufficiently asymmetric, then the players' best response functions are well behaved and a unique equilibrium in pure strategies exists [part (a) of the proposition]. Conversely, if the sharing rule used to divide output is sufficiently close to one-half, then there exists a set of Pareto-rankable Nash equilibria in pure strategies [part

⁸That we have $\mu > 1$ follows from the assumption of our distributional model that $\rho > \sigma$. Note that this assumption is satisfied irrespective of whether one is interested in "competitive preferences", "difference-averse preferences" or "social welfare preference".

⁹For the sake of simplicity, the proposition establishes all possible equilibrium configurations for the case in which γ_B is strictly positive. This requires that $\sigma > \hat{\sigma}$, where $\hat{\sigma} = -\frac{1-\pi}{2\pi-1}$. All behavioral predictions that are to follow continue to hold in the case where $\sigma \leq \hat{\sigma}$. A detailed proof is contained in appendix A.

(b) of the proposition]. In each equilibrium, the investments chosen by A and B lead to an equalization of their respective payoffs.

In order to generate behavioral predictions, we now contrast the investment incentives of self-interested players with those of individuals who are either inequity-averse or care about social welfare. In so doing, we focus purely on the parameters used in our experiment. We use the term *simultaneous overinvestment* to describe a situation in which the investments chosen by both players exceed those of self-interested individuals. Similarly, the notion *simultaneous underinvestment* denotes outcomes in which both players choose investment levels that are lower than those chosen by their selfish counterparts. For sharing rules that are bounded away from one-half, we have:

Prediction 1 (Asymmetric Sharing Rules) *If the sharing rule used to divide output is asymmetric ($\pi = 0.708$ in ASYM-C and $\pi = 0.748$ in ASYM-NC) then:*

- (a) *If players are motivated by inequity aversion ($\sigma < -\rho < 0$) or have competitive preferences ($\sigma \leq \rho \leq 0$), then there is simultaneous underinvestment in equilibrium.*
- (b) *If players are concerned about social-welfare ($1 \geq \rho \geq \sigma > 0$), then there is simultaneous overinvestment in equilibrium.*

Proof. See appendix A.3.

These results are driven by the complementarity in our investment game. Suppose both players display inequity aversion and consider the self-interest Nash equilibrium prediction as a starting point.¹⁰ The only way a player of type B can reduce payoff differences is by decreasing her investment; knowing this, and given that A is less concerned than B about inequality ($\sigma < -\rho < 0$), A 's best reply is to also lower her investment. The iteration of this kind of reasoning results in a Pareto-inferior equilibrium with respect to the Nash prediction based on self-interested players. Now consider players who display social-welfare preferences. Then player A has an incentive to raise her investment, with respect to the rational Nash equilibrium, thus increasing joint payoffs while keeping ahead of her opponent. Knowing this, B 's best reply is to raise her investment as well, thus

¹⁰Similar points hold when individuals exhibit competitive preferences.

Table 6 Behavioral Predictions

	Simultaneous underinvestment (1)		Simultaneous overinvestment (2)	
	Parameter values	Consistent with	Parameter values	Consistent with
Asymmetric sharing rules				
ASYM-C ($\pi = 0.708$)	$\sigma < -0.05, \rho < 0.38$	IA and CP	$\sigma > 0.03, \rho > -0.11$	CSW
ASYM-NC ($\pi = 0.748$)	$\sigma < -0.03, \rho < 0.46$	IA and CP	$\sigma > 0.02, \rho > -0.20$	CSW
Symmetric sharing rules				
SYM-C ($\pi = 0.491$)	$\sigma < -0.51 \cdot \rho - 0.06$	IA and CP	$\sigma > 0.02 - 1.2 \cdot \rho$	IA and CSW
SYM-NC ($\pi = 0.483$)	$\sigma < 0.05, \rho < -0.01$	CP	$\sigma > 0.02, \rho > -0.05$	CSW
IA=inequity aversion; CSW=concern for social welfare; CP=competitive preferences.				

provoking an even higher increase in A 's choice which augments her own payoff. This leads to an equilibrium that Pareto-dominates the self-interest Nash prediction.

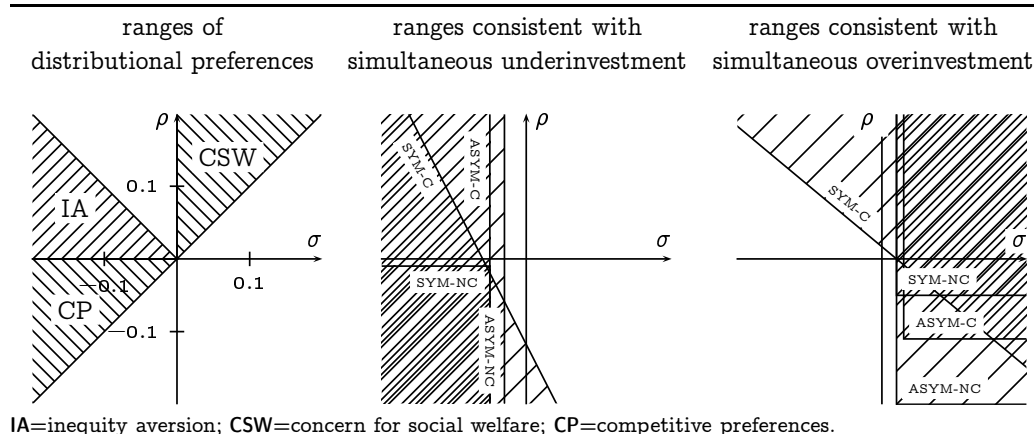
The above discussion assumes that the sharing rule used to divide output is sufficiently asymmetric. For sharing rules that are close to one-half, we have the following:

Prediction 2 (Symmetric Sharing Rules) *If the sharing rule used to divide output is close to one-half ($\pi = 0.491$ in SYM-C and $\pi = 0.483$ in SYM-NC) then:*

- (a) *If players have competitive preferences ($\sigma \leq \rho \leq 0$), then there is simultaneous underinvestment in equilibrium.*
- (b) *If players are motivated by inequity aversion ($\sigma < 0 < \rho < 1$ and $|\sigma| > \rho$), then there can be simultaneous underinvestment and simultaneous overinvestment in equilibrium.*
- (c) *If players are concerned about social-welfare ($1 \geq \rho \geq \sigma > 0$), then there is simultaneous overinvestment in equilibrium.*

Proof. See appendix A.4.

While our theoretical predictions are derived from the continuous choice problem that underlies our experiment, they carry over to the discrete investment game that our players face in the laboratory. Assuming that players have distributional preferences, Table 6 gives necessary conditions on σ and ρ for the existence of an equilibrium in our discrete choice experiment in which both A and B either underinvest (column 1) or overinvest

Figure 4 Behavioral Predictions — Illustration of Table 6

(column 2) compared to self-interested individuals. Figure 4 illustrates the table.

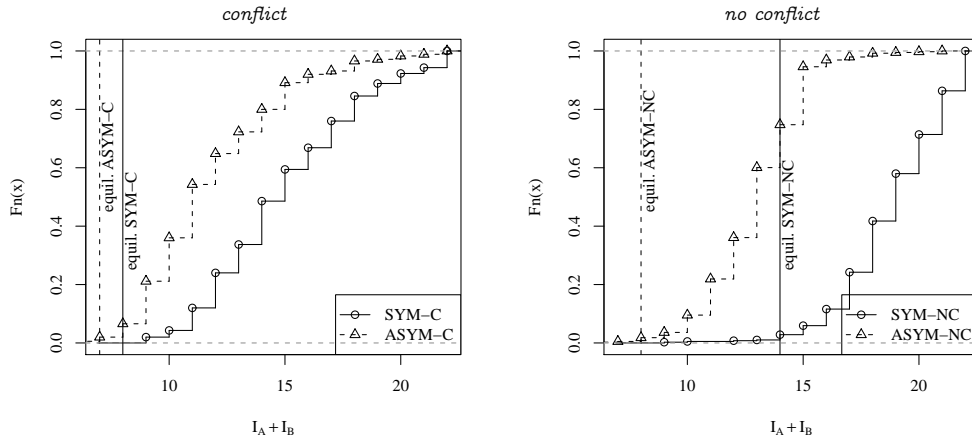
With the help of these conditions we can now relate behavior in the experiment to preferences. In all four treatments simultaneous overinvestment as an equilibrium outcome is consistent with concerns for social welfare. Conversely, simultaneous underinvestment as an equilibrium outcome is consistent with either a competitive preference or an intrinsic preference to minimize differences in payoffs.

Overall, our investment game with asymmetric sharing rules allows us to disentangle social-welfare concerns from inequality aversion and competitive preferences. Differently from numerous other experiments in which a Pareto-improvement also decreases inequality¹¹, in our case the only way inequality averse players can lower payoff differences is by investing even less efficiently than selfish individuals. On the other hand, if players are concerned about social-welfare they will raise their investment compared to self-interested players.

5 Results

We now turn to a detailed examination of the experimental data. We consider investment choices under fixed contracts in Section 5.1, discuss the consistency of expectations and behavior in Section 5.2, and examine the effects of endogenizing sharing rules in Section 5.3.

¹¹See Charness and Rabin (2002) for a discussion.

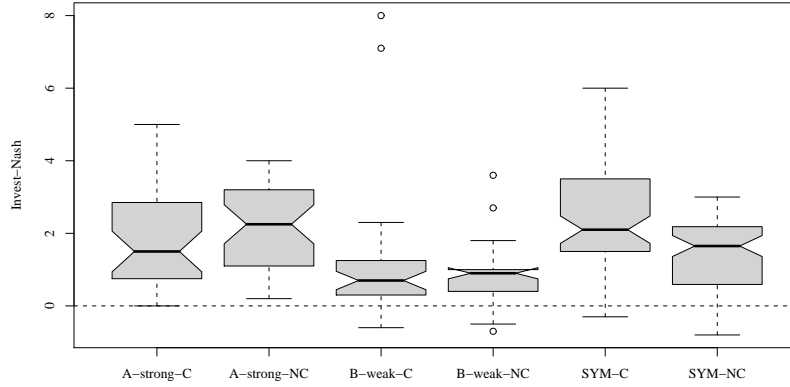
Figure 5 Investments under Fixed Contracts

5.1 Fixed Contracts

We begin by examining investment choices when contracts are fixed. In so doing, we exploit the data collected during treatments ASYM and SYM for both configurations *conflict* and *no conflict*. As we mentioned earlier, if players follow standard equilibrium predictions, then no sharing rule would induce first best investments. However, symmetric sharing rules are predicted to provide better aggregate investment incentives than asymmetric sharing rules. This prediction is confirmed by our results. Figure 5 shows the cumulative distribution of investments in both treatments under *conflict* and *no conflict* respectively. Under both configurations we observe that aggregate investments are substantially lower in ASYM, i.e. when one individual appropriates a large portion of the total benefits accruing from the partnership. This confirms one of the central insights of the modern property rights approach (Grossman and Hart, 1986; Hart and Moore, 1990), namely that the allocation of power in partnerships is important for investment incentives. We record this in the following.

Result 1 *Aggregate investments are higher under symmetric sharing rules than under asymmetric sharing rules.*

The key issue motivating our experiment lies in understanding the behavioral motives that enter partners' investment behavior under symmetric and asymmetric power structures. To get at this issue, we now compare investment behavior in the experiment with equilibrium investments of

Figure 6 Average investments (over Nash investment) per player

selfish players. Figure 6 shows the difference between average investment and Nash equilibrium investment for both players and both treatments (under both parameter configurations) as a boxplot. Note that investment under *conflict* and *no conflict* is fairly similar. Both types of players invest more than predicted by Nash equilibrium, although overinvestment is higher among strong (A) players or with a symmetric sharing rule.

We can provide a more formal analysis of the behavioral patterns observed in Figure 6. To do so, we call I_{ij} the investment of player i in period j during a given treatment (either SYM or ASYM). Moreover, let I^N be the respective Nash equilibrium investment levels. We then estimate the following equation:

$$\bar{I} - I^N = \beta_1 + \beta_{SYM} \cdot d_{SYM} + \beta_{strong} \cdot d_{strong} + u_s + u_{ij} \quad (11)$$

Sessions are indexed with s , players are indexed with i , and different periods have the index j . To simplify the notation we do not write indices ij for variables. Throughout the paper and unless specified otherwise we estimate mixed effect models with a random effect for session u_s where we assume that error terms u_s and u_{ij} follow a normal distribution with mean zero.

The dummy variable d_{SYM} is one for symmetric power sharing and zero otherwise, d_{strong} is one for the strong player (A) under asymmetric sharing rules and zero otherwise. The reference group is, hence, weak players (B) under asymmetric power sharing. We estimate equation (11) separately for *conflict* and *no conflict*. Results are shown in Tables 7 and 8.

Table 7 Estimation of equation 11 for *conflict*

	β	σ	t	p value	95% conf	interval	pmvd
1	0.777	0.235	3.31	0.0010	0.316	1.24	
d_{SYM}	1.65	0.0904	18.3	0.0000	1.47	1.83	0.845
d_{strong}	0.817	0.104	7.83	0.0000	0.612	1.02	0.155

Table 8 Estimation of equation 11 for *no conflict*

	β	σ	t	p value	95% conf	interval	pmvd
1	0.522	0.182	2.88	0.0040	0.166	0.878	
d_{SYM}	0.963	0.0611	15.8	0.0000	0.843	1.08	0.351
d_{strong}	1.51	0.0705	21.4	0.0000	1.37	1.65	0.649

To assess the impact of coefficients on the variance of our dependent variable we use as a measure of relative importance the proportional marginal value decomposition (pmvd) as proposed by Feldman (2005) using the implementation of Grömping (2007). Other measures of relative importance (such as lmr, which was made popular by Kruskal (1987)) yield similar results.

- Result 2** (a) Under both symmetric and asymmetric sharing rules, strong (A) and weak (B) players overinvest on average.
- (b) With ASYM, strong (A) players overinvest more than weak (B) players.
- (c) With SYM, players invest more than weak (B) players under ASYM.

The first part of this result follows from the positive coefficients in Tables 7 and 8. The second and third parts are implied by a positive β_{strong} and a positive β_{SYM} , respectively.

The above discussion indicates that players' investments deviate from equilibrium investments of selfish players. We now check whether distributional preferences can explain our observations. More precisely, in light of the predictions we formulated in Section 4, we want to explore whether players' behavior is consistent with either inequity aversion, social welfare or competitive preferences. To do this we look at frequencies of pairs of investments that were smaller, equal or larger than Nash equilibrium. From

Table 9 Frequencies of choices

<i>no conflict</i>					<i>conflict</i>				
		ASYM-NC player A					ASYM-C player A		
player B		<	=	>	player B		<	=	>
	<	1	6	31		<	1	6	29
	=	7	32	70		=	4	15	82
	>	13	29	161		>	9	29	213
		SYM-NC player A					SYM-C player A		
player B		<	=	>	player B		<	=	>
	<	0	3	15		<	3	4	18
	=	1	4	23		=	6	7	23
	>	4	37	263		>	27	70	230

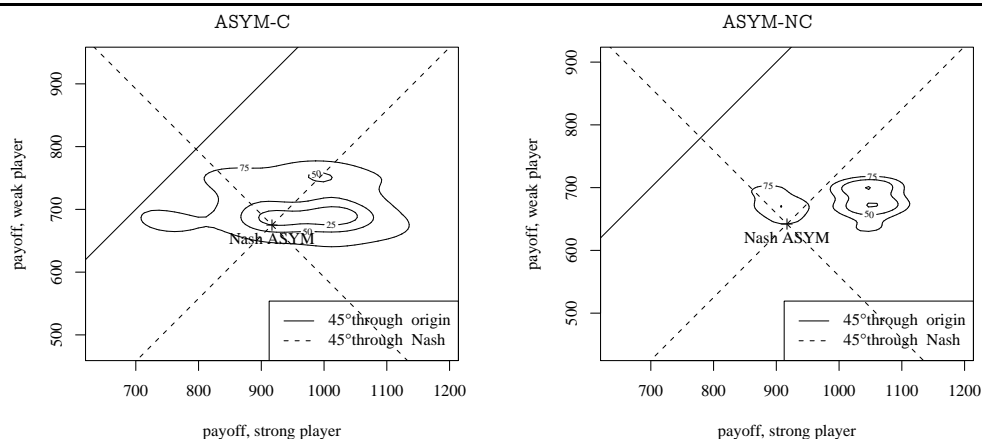
The tables show for the different treatments the frequency of pairs of choices where players' investments were smaller (<), equal (=), or larger (>) than Nash equilibrium investments.

Table 9 we see that under either parameter configuration simultaneous overinvestment of both players is the most likely scenario in both treatments. In all cases the majority of pairs simultaneously invests more than Nash equilibrium. The second highest frequency of choices in ASYM-C and ASYM-NC consists of overinvestment by the strong player, while the weak player invests less or equal than Nash equilibrium. On the contrary, in SYM-C and SYM-NC the second most likely scenario corresponds to Nash equilibrium investment by one player and overinvestment by the other¹².

Focusing on asymmetric sharing rules we can already conclude that neither inequity aversion nor competitive preferences can explain players' behavior. Indeed, recall from Prediction 1 that inequity averse players would not simultaneously overinvest under ASYM. However, the observed behavior is consistent with social welfare preferences. Furthermore, notice that the hypothesis of concern for social welfare is also consistent with overinvestment of both partners under symmetric contract. This is summarized in the following result:

Result 3 *Players' behavior is consistent with social welfare preferences, while it cannot be explained by either inequality aversion or competitive*

¹²Note that it is in particular player *B* who is overinvesting most of the time. This is understandable since *B* players, who are strongly disadvantaged in ASYM, have a small advantage with SYM

Figure 7 Payoff distributions under asymmetric sharing rules

preferences.

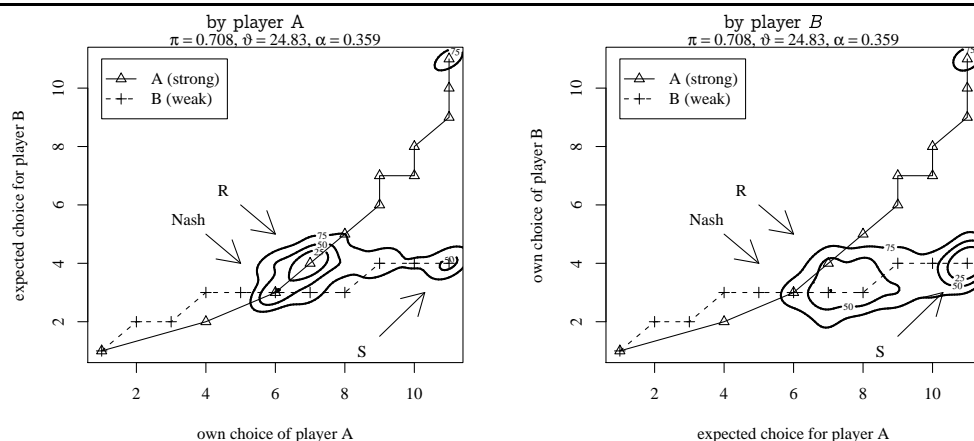
As a consequence of the simultaneous overinvestment of both players, in the majority of cases payoffs are higher than predicted by Nash equilibrium. However, it is not obvious whether players' behavior decreases payoff inequality under asymmetric sharing rules. Figure 7 shows Kernel density estimates of the distribution of payoffs for the weak and for the strong player in ASYM. We clearly see that the actual allocations are typically more efficient than Nash equilibrium allocations. However, they often become even more unequal than the (already unequal) Nash equilibrium allocation. For the ASYM treatments inequality in the experiment (measured as payoff ratio) is 5.4% larger on average than inequality under the Nash equilibrium.¹³ Interestingly, these results do support the general findings outlined in Charness and Rabin (2002). We summarize this in the following:

Result 4 *When asymmetric sharing rules are employed, payoff allocations are typically more efficient, but more unequal than the self-interest equilibrium allocation.*

5.2 Expectations and Behavior

To better understand the results described above, we analyze players' expectations in the fixed contract treatments. Figures 8 and 9 report contour

¹³This is significantly different from zero with a p -value of 2.5%.

Figure 8 Kernel densities of choices and expectations in ASYM-C

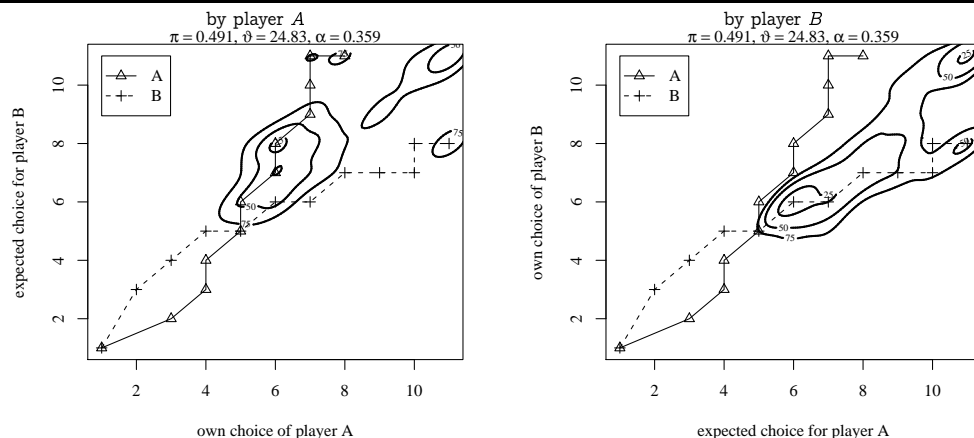
lines of estimations of two dimensional kernel densities of choices and expectations for ASYM-C and SYM-C respectively. These figures also include the best reply functions as already shown in Figure 1.¹⁴

Let us start with the left hand graph in Figure 8. This graph shows choice and expectations of type *A* players, i.e. players who get a share of $\pi = 0.708$. With selfish players equilibrium choices and expectations would be given by the intersection of the two best reply curves, i.e. the point marked “Nash” in the graph. While some choices and expectations are consistent with this point, a peak of the distribution can be found at point *R*. This point describes a situation where a type *A* player expects an investment of 4 by the opponent (i.e. more than equilibrium) and chooses a best reply (i.e. 7). A second peak of the distribution can be found at point *S*. Here expectations of the type *A* player are the same as in point *R* (a moderate overinvestment of the type *B* player), however the choice is full investment.

The right hand graph in Figure 8 shows choices and expectations of type *B* players. These choices and expectations are surprisingly consistent with those of player *A*. The only exception is type *B* players expects type *A* players to invest slightly more than what type *A* players actually do.

It is interesting to note that these expectations, and subsequent choices, are consistent with the equilibrium prediction when players display concern

¹⁴As best reply functions are closer to each other under *no conflict*, the relative figures are less instructive and we do not show them for the sake of brevity

Figure 9 Kernel densities of choices and expectations in SYM-C

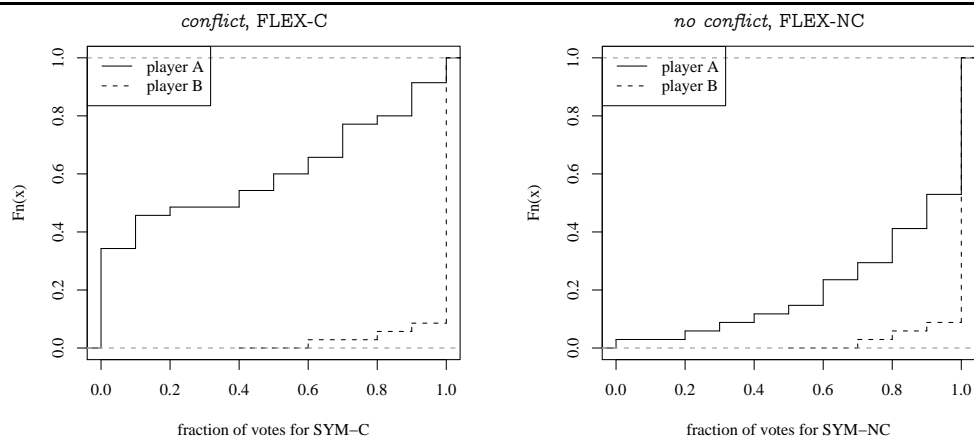
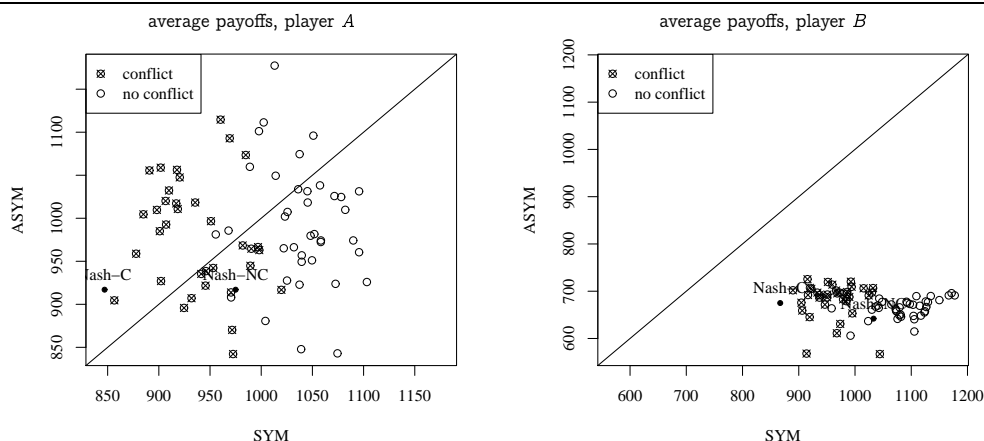
for social welfare. Strong players invest well above the self-interest Nash equilibrium level, and expect a slight overinvestment of their weak opponents. On the other hand, weak players expect their opponents to choose investments above the self-interest Nash equilibrium, and reply by slightly overinvesting, even though not as much as their opponents.

Figure 9 refers to the symmetric contract. We can see that a large part of players expect their opponents to invest more than Nash equilibrium and best reply accordingly by overinvesting. As in the asymmetric case, this pattern is also consistent with the hypothesis that individuals display social welfare preferences. We summarize these findings in the following result:

Result 5 *Players' expectations of their partners' choices are generally consistent with the actual investments undertaken. Furthermore, players' expectations, and their consequent choices, are compatible with the hypothesis of social welfare preferences.*

5.3 Flexible contracts

The last part of the experiment is the situation FLEX where players can choose what kind of sharing rule to adopt. Figure 10 reports the distribution of votes for the symmetric contract over time, under either parameter configuration. A first important result is that players are clearly guided by the rational equilibrium prediction. *B* players, who in equilibrium ben-

Figure 10 Fraction of votes for SYM**Figure 11** Average payoffs in SYM and ASYM

efit from the symmetric contract both in FLEX-C and FLEX-NC, almost always vote in favor of this sharing rule. *A* players, who in equilibrium benefit from the symmetric contract only in FLEX-NC, support the equal division under this configuration much more often than in FLEX-C. This finding is reported in the following result:

Result 6 *Weak players almost always vote in favor of symmetric sharing rules. Strong players agree to share power much more often in FLEX-NC than in FLEX-C. This pattern is consistent with standard game theoretical predictions.*

Table 10 Estimation of equation 12 for player *A*

	β	σ	z	p value	95% conf	interval
1	-1.83	0.939	-1.95	0.0508	-3.67	0.00645
r	2.64	0.863	3.05	0.0023	0.945	4.33
$d_{\text{confl.}}$	-1.06	0.366	-2.89	0.0038	-1.77	-0.342

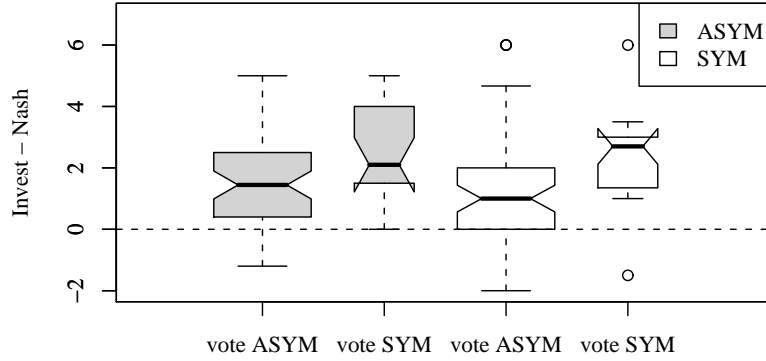
Nevertheless, it is interesting to notice that, in FLEX-C, about 66 % of strong players vote in favor of the symmetric contract at least once. This heterogeneity can be interpreted in the light of our previous findings. Recall that before playing the flexible contract game, players had experienced both the symmetric and asymmetric contract. Since *B* players often care about social welfare, several *A* players received even in the *conflict* treatment higher payoffs under SYM than under ASYM. Figure 11 shows the average payoffs players experienced in these stages. While in the *no conflict* treatment for 76% of all participants payoffs were higher in SYM than in ASYM, even in the *conflict* treatment 43% of all participants had average payoffs that were higher in SYM than in ASYM. This was not least a consequence of the overinvestment by *B* players under SYM, which is consistent with social welfare preferences. Since these *A* players made such a good experience with SYM in the first part of the game, it is natural that they also voted for SYM when they could. These players would be willing to invest more than the rational Nash level and, at the same time, would expect to be recompensed by their partners' higher investments.

To test this more formally, we estimate a mixed effects probit model.

$$P(SYM) = \Phi(\beta_1 + \beta_r \cdot r + \beta_{\text{confl.}} \cdot d_{\text{confl.}} + u_s + u_{ij}) \quad (12)$$

We call r the ratio of payoffs $r = \bar{\pi}_{SYM} / \bar{\pi}_{ASYM}$ which was experienced in the previous stages of the game. The dummy $d_{\text{confl.}}$ is one in *conflict* and zero in *no conflict*. We include a noise term for session u_s and one for individual decisions u_{ij} . Results are shown in table 10. As we should expect the coefficient of r is positive and significant: the larger the relative profits under SYM in the first stage of the game are, the higher the probability that an *A* player votes in the FLEX stage for SYM. Also not surprising, the coefficient of $d_{\text{confl.}}$ is negative and significant: the general inclination to vote for SYM is smaller in the *conflict* condition.

The above interpretation is supported by the following finding. Figure 12 shows the investments of the strong player depending on the choice of

Figure 12 Investments and votes of player A

The figure shows the difference between actual and Nash investment for player A depending on player A's vote and depending on the actual contract (ASYM or SYM). In this figure we pool data from *conflict* and *no conflict*.

contract (since almost all weak players choose the symmetric contract we focus on player A). We see that those players A who vote for a symmetric contract always invest significantly more than those who do not: investment levels are higher both under the ASYM and SYM regime. We record these results in the following:

Result 7 *In FLEX-C, the majority of strong (A) players agree to give up their power at least once. Strong players who vote in favor of SYM invest more than those who vote against, both in FLEX-C and FLEX-NC.*

For a formal analysis we estimate Equation 13 for the strong player (A) (for the FLEX treatment where players can choose a contract).

$$I_{i,t} - I^N = \beta_0 + \beta_{\text{SYMvote}} \cdot d_{\text{SYMvote}} + \beta_{\text{SYM}} \cdot d_{\text{SYM}} + u_s + u_{ij} \quad (13)$$

Again we estimate a mixed effect model with a random effect for session u_s . Estimation results are shown in Tables 11 and 12. The estimation results confirm what we see in Figure 12. Let us first look at the estimation for *conflict* in Table 11. As we have seen in figure 10, not all strong players cast a fair vote here. Those, however, how do, make also significantly higher investments than those who do not.

The same holds for *no conflict* shown in Table 12. There, however, the effect is much smaller and explains a smaller part of the variance. We should keep in mind that in *no conflict* it is in the own interest of the

Table 11 Estimation of equation 13 for player A, *conflict*

	β	σ	t	p value	95% conf interval	pmvd
1	0.876	0.296	2.96	0.0032	0.294 1.46	
$d_{SYMvote}$	1.15	0.162	7.08	0.0000	0.83 1.47	0.627
d_{SYM}	0.857	0.136	6.31	0.0000	0.591 1.12	0.373

Table 12 Estimation of equation 13 for player A, *no conflict*

	β	σ	t	p value	95% conf interval	pmvd
1	1.65	0.301	5.48	0.0000	1.06 2.24	
$d_{SYMvote}$	0.252	0.139	1.81	0.0710	-0.0215 0.525	0.495
d_{SYM}	-0.668	0.104	-6.45	0.0000	-0.871 -0.464	0.505

strong players to move to a power sharing rule. Casting a fair vote is not a sign of a particularly other regarding preference. Hence, there is not reason to expect a specific altruistic behavior of these players.

6 Conclusion

The seminal works of Grossman and Hart (1986) and Hart and Moore (1990) have shed light on the central role played by property rights when contracts are incomplete, describing their effect on parties' incentives to undertake relationship-specific investments. Property rights can be looked at as an abstract exemplification of the way power is allocated between parties. Indeed, partnerships can be characterized by their power structure, and it is very common to observe partnerships in which one party holds more power than another. In this paper, we explored experimentally the extent to which different power structures affect incentives to make relationship-specific investments when contracts are incomplete. Despite the great attention devoted to incomplete contracts in recent years, only a limited amount of experimental evidence has been produced so far. Furthermore, to the best of our knowledge, our study represents the first attempt to analyze the effect of power structure in incomplete contracts.

We considered two equally productive players who simultaneously decide how much to invest into a joint production process. We first analyzed

the players' investment behavior when the power structure is exogenously imposed. As the players' productivity is the same, theory predicts that total investments would be lower in the presence of power imbalances and higher when power is equally shared. This result is confirmed by our experimental evidence. However, we observed significant overinvestment, with respect to the self-interest Nash prediction, both under symmetric and asymmetric conditions. With asymmetric sharing rules both types of players, even the weak one, invest more than predicted by Nash equilibrium. Nonetheless, overinvestment is higher among strong players. To better understand these results, we examined the players' expectations of their partners' choices. These are surprisingly consistent with the actual investments undertaken.

As standard game theoretical analysis fails to explain the players' investment choices, we explored the predictions and implications of different behavioral theories, namely: inequity aversion, social welfare and competitive preferences. Differently from several other experiments, our design allows us to disentangle the effect that different social preferences have over individual investment behavior. We showed that players' behavior is consistent with the hypothesis that individuals are concerned with social efficiency. Interestingly, the player's choices cannot be explained by either inequity aversion or competitive preferences. This is an important result, which confirms the main findings of Charness and Rabin (2002).

Finally we examined situations where the power structure is flexible. Starting from a condition of asymmetry, the two players can agree to switch to a symmetric sharing rule. If they disagree, the asymmetric contract is applied. We analyzed this type of flexible structure under two different conditions. In one, both players should rationally (and selfishly) agree to share power equally. In the other, strong players should not give up power in equilibrium. This prediction is partly supported by our data. Indeed, strong players choose to give up power much more often when it is rational to do so. Nevertheless, we observe power-sharing agreements even when standard game theory predicts that the strong player should retain her power. This finding can again be explained assuming that individuals display concern for social welfare.

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A Technical Appendix: Behavioral Predictions

A.1 Proof of Proposition 1

If players exhibit self-interested preferences, then each player i 's decision problem is simply to choose I_i to maximize her material payoff

$$U_i(I_A, I_B) = M - I_i + \pi_i \vartheta(I_i I_j)^\alpha \quad (14)$$

where $i \in \{A, B\}$ and $i \neq j$. The Nash equilibrium investment levels of the self-interest model, I_A^s and I_B^s , are the solutions to the first-order conditions

$$\pi \alpha S I_A^{\alpha-1} I_B^\alpha = 1 \quad \text{and} \quad (1 - \pi) \alpha S I_A^\alpha I_B^{\alpha-1} = 1 \quad (15)$$

The proposition follows immediately after solving these two equations for I_A and I_B .

A.2 Proof of Proposition 2

Now consider the two players' optimal choice of I_A and I_B when they have social preferences, i.e., when their payoffs are given by

$$V_A(I_A, I_B) = (\rho \cdot r + \sigma \cdot s) \cdot U_B(I_A, I_B) + (1 - \rho \cdot r - \sigma \cdot s) \cdot U_A(I_A, I_B) \quad (16)$$

and

$$V_B(I_A, I_B) = (\rho \cdot s + \sigma \cdot r) \cdot U_A(I_A, I_B) + (1 - \rho \cdot s - \sigma \cdot r) \cdot U_B(I_A, I_B) \quad (17)$$

where $r = 1$ and $s = 0$ if $U_A(\cdot) > U_B(\cdot)$, $r = 0$ and $s = 1$ if $U_A(\cdot) < U_B(\cdot)$, and $r = 0$ and $s = 0$ if $U_A(\cdot) = U_B(\cdot)$. We do this in detail for the case where any asymmetry in sharing rule favors player A and discriminates against player B , i.e., we focus on parameter values satisfying $\pi \geq \frac{1}{2}$. We begin with player A . Her best response function is shown in the first panel of Figure 13 below. There, $\hat{I}_A(I_B)$ is the value of I_A for which the material payoffs of the two players are equal, i.e., $\hat{I}_A(I_B)$ implicitly solves

$$\underbrace{M - I_A + \pi \vartheta(I_A I_B)^\alpha}_{U_A(I_A, I_B)} = \underbrace{M - I_B + (1 - \pi) \vartheta(I_A I_B)^\alpha}_{U_B(I_A, I_B)} \quad (18)$$

Notice that $U_A(\cdot) > [<] U_B(\cdot)$ when $I_A < [>] \hat{I}_A(I_B)$.

Also, $I_A^0(I_B) = \arg \max \sigma U_B(I_A, I_B) + (1 - \sigma)U_A(I_A, I_B)$, i.e.,

$$I_A^0(I_B) = [\gamma_A I_B^\alpha]^{\frac{1}{1-\alpha}} \quad \text{where} \quad \gamma_A = \frac{(1 - \sigma)\pi + \sigma(1 - \pi)}{1 - \sigma}, \quad (19)$$

and $I_A^1(I_B) = \arg \max \rho U_B(I_A, I_B) + (1 - \rho)U_A(I_A, I_B)$, i.e.,

$$I_A^1(I_B) = [\kappa_A I_B^\alpha]^{\frac{1}{1-\alpha}} \quad \text{where} \quad \kappa_A = \frac{(1 - \rho)\pi + \rho(1 - \pi)}{1 - \rho}. \quad (20)$$

The intersection between $\hat{I}_A(I_B)$ and $I_A^0(I_B)$ occurs at the point where

$$I_A' = [\alpha \vartheta(\gamma_A)^{1-\alpha} (\gamma_A - \varepsilon)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad I_B' = [\alpha \vartheta(\gamma_A)^\alpha (\gamma_A - \varepsilon)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (21)$$

where $\varepsilon = (2\pi - 1)/\alpha$. The intersection between $\hat{I}_A(I_B)$ and $I_A^1(I_B)$ occurs at the point where

$$\bar{I}_A = [\alpha \vartheta(\kappa_A)^{1-\alpha} (\kappa_A - \varepsilon)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad \bar{I}_B = [\alpha \vartheta(\kappa_A)^\alpha (\kappa_A - \varepsilon)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (22)$$

The bottom panel of Figure 13 shows player B 's best response function. As before, $\hat{I}_B(I_A)$ is the value of I_B for which the material payoffs of the two players are equal, i.e., $\hat{I}_B(I_A)$ implicitly solves $M - I_A + \pi \vartheta(I_A I_B)^a = M - I_B + (1 - \pi) \vartheta(I_A I_B)^a$, and $U_A(\cdot) > [<] U_B(\cdot)$ when $I_A < [>] \hat{I}_A(I_B)$. Also, $I_B^0(I_A) = \arg \max \sigma U_A(I_A, I_B) + (1 - \sigma)U_B(I_A, I_B)$, i.e.,

$$I_B^0(I_A) = [\gamma_B I_A^\alpha]^{\frac{1}{1-\alpha}} \quad \text{where} \quad \gamma_B = \frac{(1 - \sigma)(1 - \pi) + \sigma\pi}{1 - \sigma}, \quad (23)$$

and $I_B^1(I_A) = \arg \max \rho U_A(I_A, I_B) + (1 - \rho)U_B(I_A, I_B)$, i.e.,

$$I_B^1(I_A) = [\kappa_B I_A^\alpha]^{\frac{1}{1-\alpha}} \quad \text{where} \quad \kappa_B = \frac{(1 - \rho)(1 - \pi) + \rho\pi}{1 - \rho}. \quad (24)$$

The intersection between $\hat{I}_B(I_A)$ and $I_B^0(I_A)$ occurs at the point where

$$\underline{I}_A = [\alpha \vartheta(\gamma_B + \varepsilon)^{1-\alpha} (\gamma_B)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad \underline{I}_B = [\alpha \vartheta(\gamma_B + \varepsilon)^\alpha (\gamma_B)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (25)$$

The intersection between $\hat{I}_A(I_B)$ and $I_A^1(I_B)$ occurs at the point where

$$I_A'' = [\alpha \vartheta(\kappa_B + \varepsilon)^{1-\alpha} (\kappa_B)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad I_B'' = [\alpha \vartheta(\kappa_B + \varepsilon)^\alpha (\kappa_B)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (26)$$

We now note that for every player i , $i \in \{A, B\}$,

$$\underline{I}_i \geq I'_i \quad \text{and} \quad \bar{I}_i \leq I''_i \quad \text{for all} \quad \pi \geq \frac{1}{2}. \quad (27)$$

Moreover, it is readily checked that

$$\underline{I}_i \leq \bar{I}_i \quad \text{if and only if} \quad \pi \leq \bar{\pi}, \quad (28)$$

where

$$\bar{\pi} = \frac{\mu}{1 + \mu} \quad \text{where} \quad \mu = \frac{(1 - \sigma)[(1 - \alpha)(1 - \rho) + \rho\alpha]}{(1 - \rho)[(1 - \alpha)((1 - \sigma) + \sigma\alpha)]} > 1. \quad (29)$$

With these preliminaries in hand, we now derive all possible equilibrium configurations of the investment game. Consider first the case where

$$\gamma_B = \frac{(1 - \sigma)(1 - \pi) + \sigma\pi}{1 - \sigma} > 0 \quad \text{or equivalently} \quad \sigma > -\frac{1 - \pi}{2\pi - 1} \equiv \bar{\sigma}. \quad (30)$$

It should be clear from Figure 13 that in the case under consideration, there are two kinds of possible equilibrium configurations in the investment game. The first, illustrated in the top panel of Figure 14, occurs when $\pi \in [\frac{1}{2}, \bar{\pi})$, i.e., when the sharing rule used to divide output is sufficiently close to one-half. Then, $\underline{I}_i < \bar{I}_i$ for every player i , and hence there exists a closed set of Nash equilibria in pure strategies. All equilibria are located on the line $\hat{I}_B(I_A)$ where the material payoffs of the two players are equal, i.e., in every equilibrium the investments chosen by A and B lead to an equalization of their material payoffs. Clearly, the equilibrium with the highest aggregate investment is determined by the intersection of $\hat{I}_B(I_A)$ and $I_A^1(I_B)$ and therefore occurs at the point where $(I_A, I_B) = (\bar{I}_A, \bar{I}_B)$. The equilibrium with the lowest aggregate investment is determined by intersection of $\hat{I}_B(I_A)$ and $I_B^0(I_A)$ and therefore occurs at the point where $(I_A, I_B) = (\underline{I}_A, \underline{I}_B)$.

The second kind of equilibrium, shown in the bottom panel of Figure 14, occurs when $\pi \in [\bar{\pi}, 1)$, i.e., when the sharing rule used to divide output is sufficiently bounded away from one-half. Then, $\underline{I}_i \geq \bar{I}_i$ for every player i . In this case, there exists a unique interior pure-strategy equilibrium that has a particularly simple form: it is determined by the intersection of $I_B^0(I_A)$ and $I_A^1(I_0)$ and therefore given by

$$I_A^* = [\alpha\vartheta(\kappa_A)^{1-\alpha}(\gamma_B)^\alpha]^{\frac{1}{1-2\alpha}} \quad \text{and} \quad I_B^* = [\alpha\vartheta(\kappa_A)^\alpha(\gamma_B)^{1-\alpha}]^{\frac{1}{1-2\alpha}}. \quad (31)$$

Consider now the case where

$$\sigma \leq -\frac{1-\pi}{2\pi-1} \equiv \bar{\sigma}. \quad (32)$$

It is readily checked that in this case $\gamma_B \leq 0$ and $\gamma_A - \epsilon \leq 0$. As a result, for every player i , $\underline{I}_i = 0$ and $I'_i = 0$. The best response functions of player A is now $\hat{I}_A(I_B)$ if $I_A \leq \bar{I}_A$ and $I_A^1(I_B)$ if $I_A > \bar{I}_A$. The best response function of player B is $\hat{I}_B(I_A)$ if $I_B \leq I_B''$ and $I_B^1(I_A)$ if $I_B > I_B''$. It should now be clear that, irrespective of whether $\pi \in [\frac{1}{2}, \bar{\pi})$ or $\pi \in [\bar{\pi}, 1)$, there now exists a closed set of equilibria in pure strategies (see Figure 15). The equilibrium with the highest aggregate investment is determined by the intersection of $\hat{I}_B(I_A)$ and $I_A^1(I_B)$ and therefore occurs at the point where $(I_A, I_B) = (\bar{I}_A, \bar{I}_B)$. The equilibrium with the lowest aggregate investment now occurs at the point where $(I_A, I_B) = (0, 0)$.

So, to summarize, the investment game is not always well behaved; we cannot rule out multiple equilibria when the sharing rule used to divide output is close to one-half. However, it is nevertheless possible to generate behavioral predictions, conditional on the parameter configurations used in the experiment.

A.3 Proof of Prediction 1

This result contrasts the investment incentives of self-interested players with those of individuals who have social preferences under the assumption that the sharing rule used to divide output is asymmetric ($\pi = 0.708$ in ASYM-C and $\pi = 0.748$ in ASYM-NC). We now provide a proof of this result. In so doing, we focus purely on the parameter configurations used in the experiment. Moreover, we restrict our attention to parameter values satisfying and $\rho \leq \frac{1}{2}$.

- Treatment ASYM-C ($\pi = 0.708$, $\alpha = 0.359$, $\vartheta = 24.83$): For the parameter values under consideration, the equilibrium investment levels of self-interested individuals are given by

$$I_A^s = 222.62 \quad \text{and} \quad I_B^s = 91.82 \quad (33)$$

Suppose now that individuals exhibit distributional preferences. Consider first the case where

$$\sigma > -\frac{1-\pi}{2\pi-1} \equiv \bar{\sigma} \quad \Rightarrow \quad \sigma > -0.702 \quad (34)$$

The condition for the existence of a unique interior pure-strategy equilibrium is

$$0.708 \geq \frac{-(0.641 - 0.282\rho)(1 - \sigma)}{0.923\rho - 0.564\rho\sigma - 1.282 + 0.923\sigma} \equiv \bar{\pi}, \quad (35)$$

which, given $\pi = 0.708$, is satisfied for all $\sigma > -0.702$ and $\rho \leq 0.5$. In the unique interior pure-strategy equilibrium, the equilibrium investment levels are given by

$$\begin{aligned} I_A^* &= 0.026 \left[\left(\frac{0.708 - 0.416\rho}{1 - \rho} \right)^{0.641} \left(\frac{0.292 + 0.416\sigma}{1 - \sigma} \right)^{0.359} \right]^{3.546} \\ I_B^* &= 0.026 \left[\left(\frac{0.708 - 0.416\rho}{1 - \rho} \right)^{0.359} \left(\frac{0.292 + 0.416\sigma}{1 - \sigma} \right)^{0.641} \right]^{3.546} \end{aligned} \quad (36)$$

Comparing (27) and (30), it is now readily checked that

- if individuals exhibit competitive preferences ($\sigma \leq \rho \leq 0$) or inequity aversion ($\sigma < -\rho < 0$), then there is simultaneous underinvestment in equilibrium, i.e., $I_A^* < I_A^s$ and $I_B^* < I_B^s$;
- if individuals are concerned about social welfare ($\sigma \leq \rho \leq 0$), then there is simultaneous overinvestment in equilibrium, i.e., $I_A^* > I_A^s$ and $I_B^* > I_B^s$.

Consider now the case where

$$\sigma \leq -\frac{1 - \pi}{2\pi - 1} \equiv \bar{\sigma} \Rightarrow \sigma \leq -0.702. \quad (37)$$

This case is limited to competitive preferences ($\sigma \leq \rho \leq 0$) and inequity aversion ($\sigma < -\rho < 0$). For the parameter values under consideration, there exists a unique pure strategy equilibrium in which both parties invest zero.¹⁵ Thus, our previous observation that competitive preferences or inequity aversion lead to simultaneous underinvestment in equilibrium continues to hold.

¹⁵To see this, recall that, when $\sigma \leq \bar{\sigma}$, there generally exists a closed set of pure-strategy equilibria (see Figure 15). The equilibrium with the highest aggregate investments occurs where $(I_A, I_B) = (\bar{I}_A, \bar{I}_B)$. It is readily checked that, for the parameter values under consideration, $(\bar{I}_A, \bar{I}_B) = (0, 0)$. Hence both parties will choose zero investments in equilibrium.

- Treatment ASYM-NC ($\pi = 0.748$, $\alpha = 0.41$, $\vartheta = 14$): For the parameter values under consideration, the equilibrium investment levels of self-interested individuals are given by

$$I_A^s = 275.03 \quad \text{and} \quad I_B^s = 92.66 \quad (38)$$

Suppose now that individuals exhibit distributional preferences. Consider first the case where

$$\sigma > -\frac{1-\pi}{2\pi-1} \equiv \bar{\sigma} \quad \Rightarrow \quad \sigma > -0.508 \quad (39)$$

The condition for the existence of a unique interior pure-strategy equilibrium is

$$0.748 \geq \frac{-(0.59 - 0.18\rho)(1-\sigma)}{0.77\rho - 0.36\rho\sigma - 1.18 + 0.77\sigma} \equiv \bar{\pi}, \quad (40)$$

which, given $\pi = 0.748$, is satisfied for all $\sigma > -0.508$ and $\rho \leq 0.5$. In the unique interior pure-strategy equilibrium, the equilibrium investment levels are given by

$$\begin{aligned} I_A^* &= 16450.43 \left[\left(\frac{0.748 - 0.496\rho}{1-\rho} \right)^{0.59} \left(\frac{0.252 + 0.496\sigma}{1-\sigma} \right)^{0.41} \right]^{1.273} \\ I_B^* &= 16450.43 \left[\left(\frac{0.748 - 0.496\rho}{1-\rho} \right)^{0.41} \left(\frac{0.252 + 0.496\sigma}{1-\sigma} \right)^{0.59} \right]^{1.273} \end{aligned} \quad (41)$$

Comparing (27) and (30), it is now readily checked that

- if individuals exhibit competitive preferences ($\sigma \leq \rho \leq 0$) or inequity aversion ($\sigma < -\rho < 0$), then there is simultaneous underinvestment in equilibrium, i.e., $I_A^* < I_A^s$ and $I_B^* < I_B^s$;
- if individuals are concerned about social welfare ($\sigma \leq \rho \leq 0$), then there is simultaneous overinvestment in equilibrium, i.e., $I_A^* > I_A^s$ and $I_B^* > I_B^s$.

Consider now the case where

$$\sigma \leq -\frac{1-\pi}{2\pi-1} \equiv \bar{\sigma} \quad \Rightarrow \quad \sigma \leq -0.702. \quad (42)$$

This case only corresponds to competitive preferences ($\sigma \leq \rho \leq 0$) or inequity aversion ($\sigma < -\rho < 0$). As in ASYM-C, for the parameter

values under consideration, there now exists a unique pure strategy equilibrium in which both parties invest zero. Thus, our previous observation that competitive preferences or inequity aversion lead to simultaneous underinvestment in equilibrium continues to hold.

A.4 Proof of Prediction 2

This result contrasts the investment incentives of self-interested players with those of individuals who have social preferences under the assumption that the sharing rule used to divide output is symmetric ($\pi = 0.491$ in SYM-C and $\pi = 0.483$ in SYM-NC). We now provide a proof of this result. As before, we restrict our attention to parameter values satisfying and $\rho \leq \frac{1}{2}$.

- Treatment SYM-C ($\pi = 0.491$, $\alpha = 0.359$, $\vartheta = 24.83$): For the parameter values under consideration, the equilibrium investment levels of self-interested individuals are given by

$$I_A^s = 196.56 \quad \text{and} \quad I_B^s = 203.77 \quad (43)$$

Suppose now that individuals exhibit distributional preferences. Consider first parameter values for which a unique interior pure-strategy equilibrium exists:

$$\sigma > -\frac{\pi}{1-2\pi} \equiv \bar{\sigma} \quad \Rightarrow \quad \sigma > -27.28 \quad (44)$$

and

$$0.491 \leq \frac{(-0.641 - 0.282\sigma)(1-\rho)}{-1.282 + 0.923\sigma + 0.923\rho - 0.564\rho\sigma} \equiv 1 - \hat{\pi} \quad (45)$$

In the unique interior pure-strategy equilibrium, the equilibrium investment levels are given by

$$\begin{aligned} I_A^* &= 2339.09 \left[\left(\frac{0.509 - 0.018\rho}{1-\rho} \right)^{0.359} \left(\frac{0.491 + 0.018\sigma}{1-\sigma} \right)^{0.641} \right]^{3.546} \\ I_B^* &= 2339.09 \left[\left(\frac{0.509 - 0.018\sigma}{1-\sigma} \right)^{0.359} \left(\frac{0.491 + 0.018\rho}{1-\rho} \right)^{0.641} \right]^{3.546} \end{aligned} \quad (46)$$

Comparing (37) and (40), it is now readily checked that, when (38) and (39) are satisfied, then

- if individuals exhibit competitive preferences ($\sigma \leq \rho \leq 0$), then there is simultaneous underinvestment in equilibrium, i.e., $I_A^* < I_A^s$ and $I_B^* < I_B^s$;
- if individuals exhibit inequity aversion ($\sigma \leq -\rho \leq 0$), then there are two possible equilibrium outcomes. In the first, there is simultaneous underinvestment in equilibrium, i.e., $I_A^* < I_A^s$ and $I_B^* < I_B^s$. In the second, player B overinvests while player A underinvests in equilibrium, i.e., $I_A^* < I_A^s$ and $I_B^* > I_B^s$.
- if individuals are concerned about social welfare ($\sigma \leq \rho \leq 0$), then there is simultaneous overinvestment in equilibrium, i.e., $I_A^* > I_A^s$ and $I_B^* > I_B^s$.

Consider next the case in which

$$0.491 > \frac{(-0.641 - 0.282\sigma)(1 - \rho)}{-1.282 + 0.923\sigma + 0.923\rho - 0.564\rho\sigma} \equiv 1 - \hat{\pi} \quad (47)$$

In this case, there exists a closed set of pure strategy equilibria. In the equilibrium with the highest aggregate investments the players' investment levels are given by

$$\begin{aligned} I_A'' &= 2339.09 \left[\left(\frac{0.509 - 0.018\rho}{1 - \rho} \right)^{0.359} \left(\frac{0.509 - 0.018\rho}{1 - \rho} - 0.05 \right)^{0.641} \right]^{3.546} \\ I_B'' &= 2339.09 \left[\left(\frac{0.509 - 0.018\rho}{1 - \rho} - 0.05 \right)^{0.359} \left(\frac{0.509 - 0.018\rho}{1 - \rho} \right)^{0.641} \right]^{3.546} \end{aligned} \quad (48)$$

In the equilibrium with the lowest aggregate investments the players' investment levels are given by

$$\begin{aligned} I_A' &= 2339.09 \left[\left(\frac{0.491 + 0.018\sigma}{1 - \sigma} + 0.05 \right)^{0.359} \left(\frac{0.491 + 0.018\sigma}{1 - \sigma} \right)^{0.641} \right]^{3.546} \\ I_B' &= 2339.09 \left[\left(\frac{0.491 + 0.018\sigma}{1 - \sigma} \right)^{0.359} \left(\frac{0.491 + 0.018\rho}{1 - \rho} + 0.05 \right)^{0.641} \right]^{3.546} \end{aligned} \quad (49)$$

Comparing (37) with (42) and (43) respectively, it is now readily checked that, when (41) is satisfied, then

- if individuals exhibit competitive preferences ($\sigma \leq \rho \leq 0$), then there is simultaneous underinvestment both in the equilibrium with the highest aggregate investment ($I_A'' < I_A^s$ and $I_B'' < I_B^s$) and in the equilibrium with lowest aggregate investment ($I_A' < I_A^s$ and $I_B' < I_B^s$).
 - if individuals exhibit inequity aversion ($\sigma \leq -\rho \leq 0$), then there is simultaneous overinvestment in the equilibrium with the highest aggregate investment ($I_A'' > I_A^s$ and $I_B'' > I_B^s$) and simultaneous underinvestment in the equilibrium with lowest aggregate investment ($I_A' < I_A^s$ and $I_B' < I_B^s$).
 - if individuals are concerned about social welfare ($\sigma \leq \rho \leq 0$), then there is simultaneous overinvestment both in the equilibrium with the highest aggregate investment ($\bar{I}_A > I_A^s$ and $\bar{I}_B > I_B^s$) and in the equilibrium with lowest aggregate investment ($\underline{I}_A > I_A^s$ and $\underline{I}_B > I_B^s$).
- Treatment SYM-NC ($\pi = 0.483$, $\alpha = 0.41$, $\vartheta = 14.00$): For the parameter values under consideration, the equilibrium investment levels of self-interested individuals are given by

$$I_A^s = 336.99 \quad \text{and} \quad I_B^s = 360.72 \quad (50)$$

Suppose now that individuals exhibit distributional preferences. Consider first parameter values for which a unique interior pure-strategy equilibrium exists:

$$\sigma > -\frac{\pi}{1-2\pi} \equiv \bar{\sigma} \quad \Rightarrow \quad \sigma > -14.21 \quad (51)$$

and

$$0.483 \leq \frac{-(0.59 - 0.18\sigma)(1 - \rho)}{(-1.18 + 0.77\sigma + 0.77\rho - 0.36\rho\sigma)} \equiv 1 - \hat{\pi} \quad (52)$$

In the unique interior pure-strategy equilibrium, the equilibrium investment levels are given by

$$\begin{aligned} I_A^* &= 16450.43 \left[\left(\frac{0.517 - 0.034\rho}{1 - \rho} \right)^{0.41} \left(\frac{0.483 + 0.034\sigma}{1 - \sigma} \right)^{0.59} \right]^{5.56} \\ I_B^* &= 16450.43 \left[\left(\frac{0.517 - 0.034\rho}{1 - \rho} \right)^{0.59} \left(\frac{0.483 + 0.034\sigma}{1 - \sigma} \right)^{0.41} \right]^{5.56} \end{aligned} \quad (53)$$

Comparing (44) and (47), it is now readily checked that, when (38) and (39) are satisfied, then

- if individuals exhibit competitive preferences ($\sigma \leq \rho \leq 0$), then there is simultaneous underinvestment in equilibrium ($I_A^* < I_A^s$ and $I_B^* < I_B^s$).
- if individuals exhibit inequity aversion ($\sigma \leq -\rho \leq 0$), then there are three possible equilibrium outcomes. On the one hand, there may be either simultaneous underinvestment ($I_A^* < I_A^s$ and $I_B^* < I_B^s$) or simultaneous overinvestment ($I_A^* > I_A^s$ and $I_B^* > I_B^s$) in equilibrium. On the other hand, it may also be the case that player B overinvests while player A underinvests in equilibrium ($I_A^* < I_A^s$ and $I_B^* > I_B^s$).
- if individuals are concerned about social welfare ($\sigma \leq \rho \leq 0$), then there is simultaneous overinvestment in equilibrium ($I_A^* > I_A^s$ and $I_B^* > I_B^s$).

Consider next the case in which

$$0.483 > \frac{-(0.59 - 0.18\sigma)(1 - \rho)}{(-1.18 + 0.77\sigma + 0.77\rho - 0.36\rho\sigma)} \equiv 1 - \hat{\pi} \quad (54)$$

In this case, there exists a closed set of pure strategy equilibria. In the equilibrium with the highest aggregate investments the players' investment levels are given by

$$\begin{aligned} I_A'' &= 1645^{0.43} \left[\left(\frac{0.517 - 0.034\rho}{1 - \rho} \right)^{0.41} \left(\frac{0.517 - 0.034\rho}{1 - \rho} - 0.08 \right)^{0.59} \right]^{5.56} \\ I_B'' &= 1645^{0.43} \left[\left(\frac{0.517 - 0.034\rho}{1 - \rho} - 0.08 \right)^{0.41} \left(\frac{0.517 - 0.034\rho}{1 - \rho} \right)^{0.59} \right]^{5.56} \end{aligned} \quad (55)$$

In the equilibrium with the lowest aggregate investments the players' investment levels are given by

$$\begin{aligned} I_A' &= 1645^{0.43} \left[\left(\frac{0.483 + 0.034\sigma}{1 - \sigma} \right)^{0.59} \left(\frac{0.483 + 0.034\sigma}{1 - \sigma} + 0.08 \right)^{0.41} \right]^{5.56} \\ I_B' &= 1645^{0.43} \left[\left(\frac{0.483 + 0.034\sigma}{1 - \sigma} + 0.08 \right)^{0.59} \left(\frac{0.483 + 0.034\sigma}{1 - \sigma} \right)^{0.41} \right]^{5.56} \end{aligned} \quad (56)$$

Comparing (44) with (49) and (50) respectively, it is now readily checked that, when (41) is satisfied, then

- if individuals exhibit competitive preferences ($\sigma \leq \rho \leq 0$), then there is simultaneous underinvestment both in the equilibrium with the highest aggregate investment ($I''_A < I^s_A$ and $I''_B < I^s_B$) and in the equilibrium with lowest aggregate investment ($I'_A < I^s_A$ and $I'_B < I^s_B$).
- if individuals exhibit inequity aversion ($\sigma \leq -\rho \leq 0$), then there is simultaneous overinvestment in the equilibrium with the highest aggregate investment ($I''_A > I^s_A$ and $I''_B > I^s_B$) and simultaneous underinvestment in the equilibrium with lowest aggregate investment ($I'_A < I^s_A$ and $I'_B < I^s_B$).
- if individuals are concerned about social welfare ($\sigma \leq \rho \leq 0$), then there is simultaneous overinvestment both in the equilibrium with the highest aggregate investment ($\bar{I}_A > I^s_A$ and $\bar{I}_B > I^s_B$) and in the equilibrium with lowest aggregate investment ($\underline{I}_A > I^s_A$ and $\underline{I}_B > I^s_B$).

B Conducting the experiment and instructions

The experiment was run at the Laboratory of the School of Economics at the University of Jena. Participants were recruited by email with Orsee (Greiner, 2004) and could register for the experiment on the internet. At the beginning of the experiment participants drew balls from an urn to determine their allocation to seats. When seated participants then obtained written instructions in German. In the following we give a translation of the instructions.

After answering control questions on the screen subjects entered the treatment described in the instructions. After completing the treatment they answered a short questionnaire on the screen and where then paid in cash. The experiment was done with the help of z-Tree (Fischbacher (2007)).

Instructions to the experiment

You are participating in a scientific experiment that is sponsored by the University of Jena and the University of St Andrews in Scotland. The instructions are simple. If you read them carefully then you can—depending on your decision—gain a considerable amount of money which is paid to you at the end of the game.

Your payoff depends on your success in the experiment. During the experiment you gain a certain number of “ECU” (Experimental Currency Units). At the end of the experiment you will be paid in €. The conversion rate is $1 \text{ €} = 2000 \text{ ECU}$.

When you have questions, then please raise your hand. We will come to you and answer your question. All participants of the experiment receive the same instructions. The information on the screen is, however, only for the individual participant. You are not allowed to have a look at the screen of other participants and you are not allowed to talk to other participants. Please concentrate on the experiment, do not read anything you brought with you, do not try to start any other programs on the computer, do not use your mobile phone. If you do not follow these rules you are excluded from the experiment and you will not be paid.

You will play several rounds. In each round you play together with a randomly selected other player. In each round you and the other player choose each one number. Depending on the numbers you choose you receive a payoff in “ECU” which is determined according to a table. The following example shows only a part of a table, in the experiment you see a complete table.

		number the other player has chosen				
		5	6	7	8	9
your number	4	.	.	.	.	.
	5	.	.	.	.	.
	6	.	.	¹² 11	.	.
	7	.	.	.	.	.
	8	.	.	.	.	.

With your number you choose a row in the table. The other player chooses with his number a column in the table. The intersection determines a cell. In the example, when you choose row 6 and the other player column 7, then your payoff is according to the cell

¹² 11

. Your payoff is the

boldface number at the bottom left (11), the payoff of the other player is the number at the top right (12). With the help of the table you can determine your payoff for any combination of rows and columns. Your payoff is, hence, determined by the number you have chosen and by the number the other player has chosen.

To help you understand the experiment, please do the following:

- Click a number at the beginning of row as well as a number at the top of a column. The row and the column will be shown in red. The cell at the intersection will be circled.

The row you have chosen corresponds to your number. The column you have chosen corresponds to the number you expect the other player will chose.

- Of course, your expectation of what number the other player might choose neither affects your payoff nor the payoff of the other player. To make a good decision, you can nevertheless think about the possible choices of the other player.
- You can repeat this exercise as often as you wish. You can try different combinations of numbers for yourself and for the other player. When you are satisfied with your choice please push the button **OK**.

As soon as the other player has completed his decision you see on your screen which number he has chosen and which payoff he has received.

Please write these values in each round into the table that you find on the back of this instruction sheet.

Please copy your results from the game into this table (ignore superfluous columns)

round	your number	number of the other player	your expected number of the other player	your profit	profit of the other player	chosen table	used table

⋮

Figure 13 Best response functions

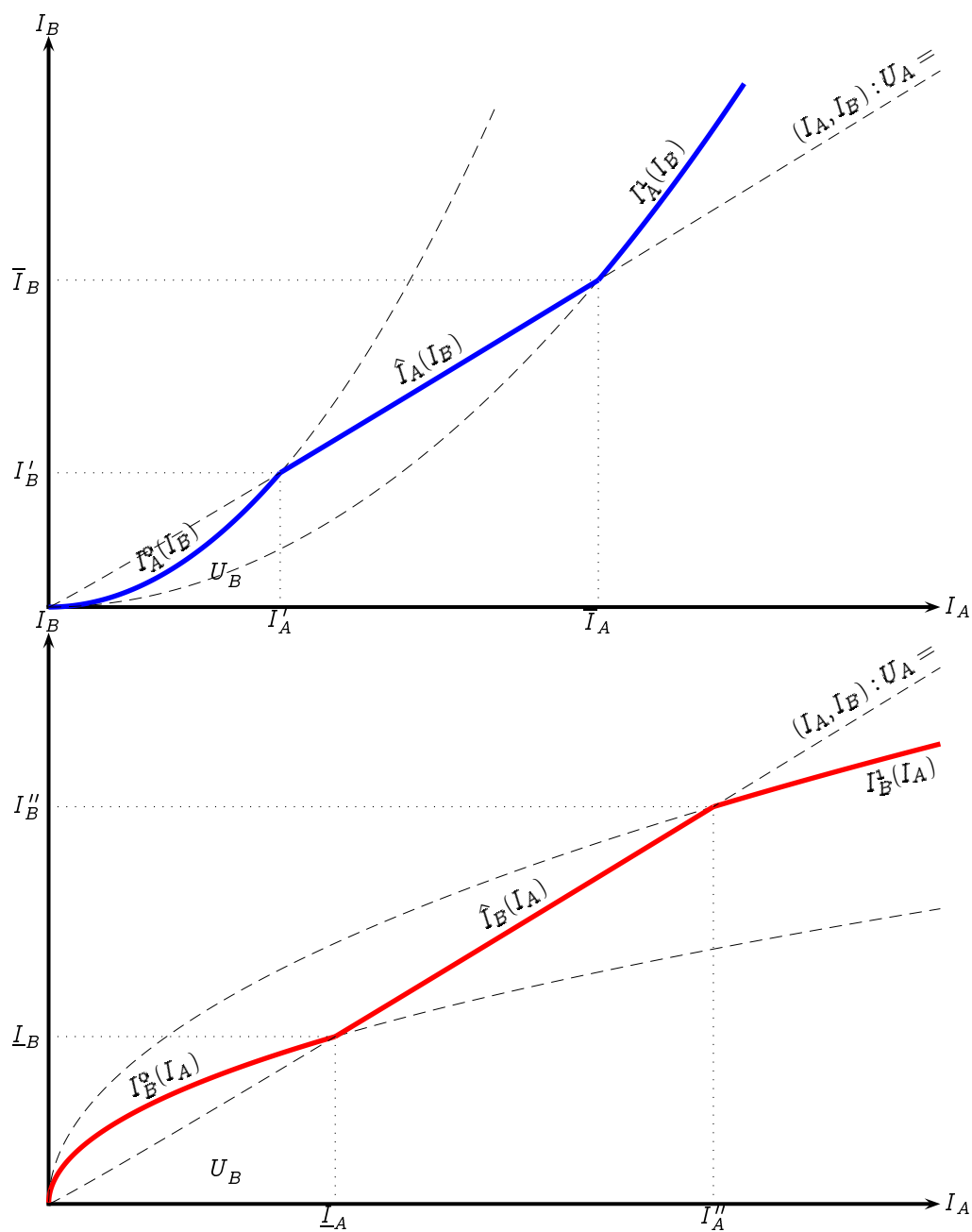


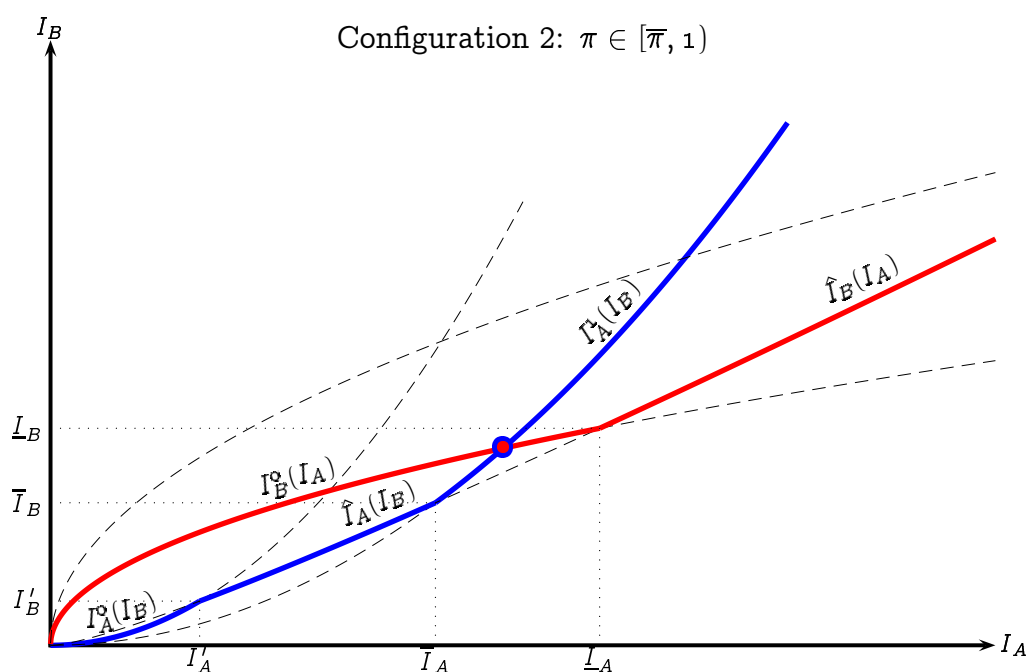
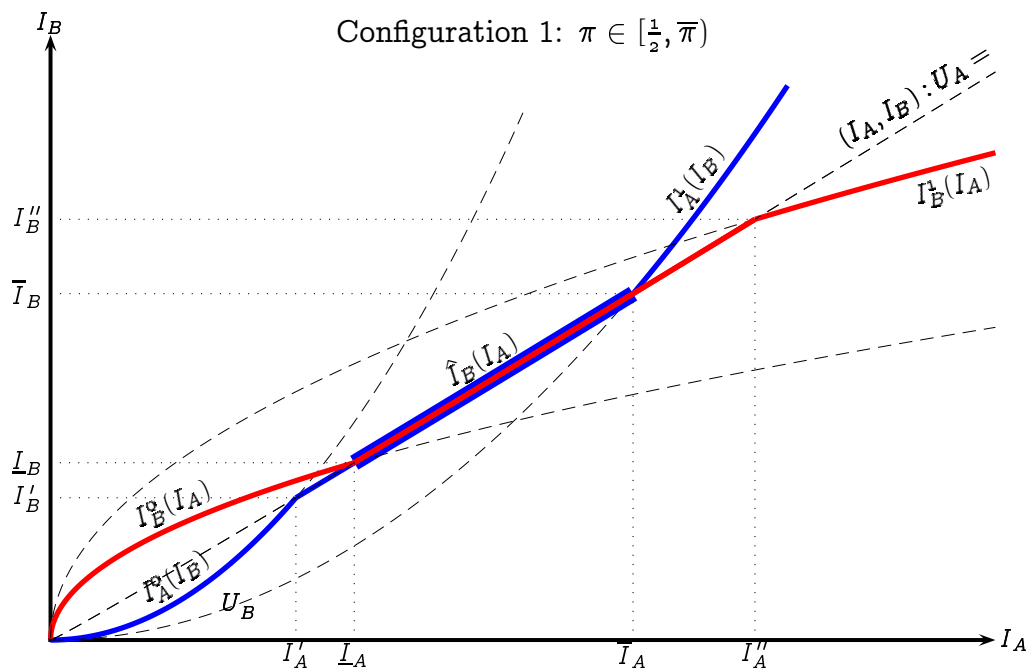
Figure 14 Two possible equilibrium configurations when $\sigma > \hat{\sigma}$ 

Figure 15 Equilibrium configuration when $\sigma \leq \hat{\sigma}$

