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# LORENZ, PARETO, PIGOU: WHO SCORES BEST?

## Experimental Evidence on Dominance Relations of Income Distributions

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**Abstract**

Using an experiment with material incentives, this paper investigates the violation of composite dominance relationships, viz. absolute Pareto dominance, Pareto rank dominance, transfer dominance, Lorenz dominance, and generalized Lorenz dominance. Moreover, we test tail independence. The experiment consists of two treatments, a self–concern mode (in which each subject expects payoffs according to her own choices), and a social–planner mode (in which subjects form their preferences without any chance of receiving payoffs when they became effective). The main focus of this paper centers on the behavioral shifts between the self–concern and the social–planner modes. We show, first, that subjects' behavior is different under the two treatments. Second, we show that there are less violations of the two Pareto dominance relations and of generalized Lorenz dominance and more violations of Lorenz dominance and of transfer dominance under the self–concern mode than under the social–planner mode. Within these groups, behavior is more similar under the self–concern mode than under the social–planner mode. Tail independence is widely rejected.

JEL classification: D31, C91, D63.
Keywords: Income distributions, dominance relations, tail independence.

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# 1 Introduction

There is ample experimental evidence on subjects' compliance with distributional axioms (see, for example, Amiel and Cowell, 1992, 1994a, 1994b, 1998, 1999a, 1999b, 2000; Ballano and Ruiz–Castillo, 1993; Harrison and Seidl, 1994a, 1994b; Bernasconi, 2002). These studies have shown that the most basic axioms of inequality measurement, such as anonymity, scale invariance, translation invariance, Pigou's transfer principle, decomposability (introduced by Shorrocks, 1980), and the population principle, enjoy but modest support, which ranges between 30% and 60% of responses. Relying on experimental evidence on distributional axioms in isolation and considering that scale invariance, the transfer principle, and the population principle invoke the comparison of income distributions in terms of Lorenz curves, Amiel and Cowell (1999a, p. 43) argued that 76% of their subjects had rejected the Lorenz axiom system. When adding decomposability (which is violated by Lorenz curves), 84% of their subjects had rejected the standard axioms of inequality measurement.

This provokes the question of whether we can legitimately confine tests of violation or acceptance of composite relationships among income distributions, or of relationships which concern them as a whole, to tests of violation or acceptance of basic distributional axioms and make inferences on the more complex relationships. In particular, does the violation of several distributional axioms necessarily imply violation of Lorenz dominance? This depends on whether subjects may be regarded as perfect computers who are able to process distributional axioms perfectly to yield the Lorenz dominance relation. Otherwise, observance or rejection of Lorenz dominance has to be tested directly. If this is done, it may well be the case that subjects' direct attitudes to Lorenz dominance differ from their attitudes to its constituent

axioms.

In this paper, we expose dominance relations of income distributions to a direct experimental test. Subjects had to rank 12 income distributions involving dominance relations in terms of absolute Pareto dominance (McClelland and Rohrbaugh, 1978), Pareto rank dominance (Saposnik, 1981, 1983), transfer dominance, Lorenz dominance, and generalized Lorenz dominance (Shorrocks, 1983). While Pareto dominance captures only the efficiency aspect of income distributions, transfer dominance and Lorenz dominance focus on the equity aspect solely. Generalized Lorenz dominance takes both efficiency and equity aspects into account.

The experiment involved two different treatments: A *self–concern mode* under which subjects were responsible only for their own payoffs and a *social–planner mode* under which subjects determined the payoff chances of the other subjects without having own stakes in the income distributions. Thus, the experiment allowed us not only to investigate the acceptance of dominance relations under both modes but also to observe behavioral shifts between the self–concern and the social–planner modes. In particular, we were interested in learning whether the equity and efficiency aspects of comparing income distributions would be given different weights when changing subjects' roles. Furthermore, we tested for tail independence of the evaluation of income distributions. This test allowed us to draw conclusions with regard to subjects' perception of income distributions: Do subjects perceive income distributions in a holistic way or do they direct their attention to particular sections only?

The paper is organized as follows: The next section sets up the theoretical framework of our paper. Section 3 states the hypotheses to be tested by our experiment. In Section 4, we give a detailed description of the experiment.

Our results are presented in Section 5. Section 6 summarizes the main results and concludes the paper.

# 2 Dominance Relations of Income Distributions

The first dominance relation to be considered is Pareto dominance. Generically, Pareto dominance holds if no income recipient loses and at least one wins. There are several ways, however, to apply the Pareto principle to income distributions: Let $x = (x_1, x_2, \ldots, x_n)$ and $y = (y_1, y_2, \ldots, y_n)$ denote two increasingly ordered income distributions with equal population size. Then, a possible interpretation of Pareto dominance is given by

**Definition 1 (Pareto rank dominance (PR))** *$x$ Pareto rank dominates $y$ if $x_i \geq y_i \; \forall \; i = 1, 2, \ldots, n$ and the inequality sign is strict for at least one income recipient.*

PR is the view taken, for example, by Saposnik (1981, 1983). Obviously, PR is equivalent to first–order stochastic dominance.

However, PR harbors several difficulties. First, if also subjects' ranks within income distributions are subject to change, then an income recipient has to cope with a possibly different income rank when switching from $y$ to $x$. Consequently, worsening the position of any income recipient can only be avoided if the interporetation of Pareto dominance of $x$ over $y$ is adjusted to:

**Definition 2 (Absolute Pareto dominance (AP))** *$x$ absolutely Pareto dominates $y$ if $x \geq \Pi y$ for all permutation matrices $\Pi$, which means that $\min_i\{x_i\} \geq \max_i\{y_i\}$.*

AP is the view taken by McClelland and Rohrbaugh (1978). This variety of Pareto dominance is ruled out when individuals can rely on keeping their income rank in different income distributions.

Second, Pareto dominance has to be properly defined in terms of individual preferences or in terms of interpersonally non–comparable utilities.[1] As utility externalities have been evidenced to exist for income distributions (in the sense that an income recipient's utility depends not only on her own income but also on other persons' incomes),[2] Pareto dominance should be properly defined such that $x$ Pareto dominates $y$ if $u_i(x) \geq u_i(y) \; \forall \; i = 1, 2, \ldots, n$, one inequality sign being strict.

Utility externalities can be captured either in terms of individual utility functions or in terms of social welfare functions.[3] Alas, this approach suffers from severe pitfalls, first, because a subject's utility depends decisively on her role assumed in a distributional situation, and, second, because subjects

[1]Taking up a pioneering study of Hochman and Rodgers (1969), Amiel and Cowell (1994c) reiterated this approach. Alas, other than Hochman and Rodgers (1969), they embedded their analysis of the Pareto principle in a Bergson–Samuelsonian social welfare function which implies interpersonal comparability of utilities (of which Hochman and Rodgers were well aware). Yet the Pareto principle owes its very existence to the conviction of interpersonal non–comparability of utilities! Moreover, a Bergson–Samuelsonian social welfare function which satisfies monotonicity and violates the Pareto principle at the same time does not exist. The apparent puzzle (Amiel and Cowell, 1994c, p. 449) is brought about by applying *different* social welfare functions to monotonicity and to the Pareto principle, the latter social welfare function being implicit.

[2]Subjects have indeed exhibited aversion to advantageous inequality, that is, they have shown preference for more equal payoffs even if this implied inferior payments for themselves (see, for example, Loewenstein et al., 1989; Bazerman et al., 1992; and Charness and Grosskopf, 2001).

[3]The former approach was pioneered by Hochman and Rodgers (1969), the latter by McClelland and Rohrbaugh (1978). Amiel and Cowell (1994c) mixed up these approaches.

differ sharply in judgment and choice with respect to distributional problems.

With respect to the first pitfall, the distortion of subjects' utility functions by a self–serving or egocentric bias is well documented in experimental work (see, for example, Miller and Ross, 1975; Messick and Sentis, 1979, 1983; Ross and Sicoly, 1979; Loewenstein et al., 1993; and Babcock and Loewenstein, 1997). In a recent seminal study, Beckman et al. (2002) found that rejection of the Pareto principle increases from 10.1% to 20.6% of respondents when their position switches from behind a veil of ignorance to known positions. Moreover, for known positions, the Pareto principle is supported by 95.4% of respondents when the respondent *gains* from the move, versus a 59.3% support when a higher–ranked income recipient gains and a 69.2% support when a lower–ranked income recipient gains.

With respect to the second pitfall, experimental work has, for instance, shown that subjects express greater happiness for jobs with less pay when salaries are more equally distributed than for jobs with more pay which falls off from their mates' salaries. However, when faced with job choices, subjects opt for the higher–paid job, thereby accepting relative deprivation resulting from the unequal salaries (see, for instance, Schmitt and Marwell, 1972; Ross and McMillen, 1973; Austin et al., 1980; Tversky and Griffin, 1991; Blount and Bazerman, 1996; for field data see Clark and Oswald, 1996).

Since we were interested in comparing subjects' attitudes under two different decision modes, we decided to settle our experimental design on Saposnik's (1981) rank dominance[4] and on absolute Pareto dominance as given by Definitions 1 and 2. Using these two definitions of Pareto dominance, we set up a within–subjects experimental design which allowed us to investigate

[4]Working independently of us, Beckman et al. (2002) chose precisely the same treatment.

subjects' attitudes both under a mode of self–concern and in their roles as social planners.

The principle of transfers requires that an income distribution which results from a rank–preserving transfer from a richer to a poorer income recipient should be given preference to the original distribution. It is equivalent to a mean–and–rank–preserving contraction.

**Definition 3 (Transfer dominance (T))** *$x$ dominates $y$ according to the principle of transfers if $x$ was obtained from $y$ by a mean–and–rank–preserving contraction, that is, $x_i = y_i \;\forall\; i \neq j,k,\;\; j < k,$ and $\delta > 0$ such that $x_j = y_j + \delta \leq y_{j+1} = x_{j+1} \leq x_{k-1} = y_{k-1} \leq y_k - \delta = x_k$.*

Let $X$ denote the total income of $x$. Then the Lorenz curve of $x$ is defined by $L_x\,(j/n) = \sum_{i=1}^{j} x_i/X$ for $j = 1, 2, \ldots, n$, and we can state:

**Definition 4 (Lorenz dominance (L))** *Income distribution $x$ Lorenz dominates income distribution $y$ if $L_x(j/n) \geq L_y(j/n) \;\forall\; j = 1, 2, \ldots, n$.*

Generalized Lorenz–dominance was suggested by Shorrocks (1983). Its idea is quite simple: The Lorenz curve of an income distribution is scaled up by mean income.

**Definition 5 (Generalized Lorenz dominance (GL))** *Income distribution $x$ generalized Lorenz dominates income distribution $y$ if $\mu_x L_x(j/n) \geq \mu_y L_y(j/n) \;\forall\; j = 1, 2, \ldots, n$.*

As to the dominance relations to be tested, note that

1. absolute Pareto dominance implies Pareto rank dominance;

2. both AP and PR imply generalized Lorenz dominance[5], but do not imply Lorenz–dominance[6];

3. mean–and–rank–preserving contractions, and, thus, the transfer principle, imply both L and GL, but are not implied by them;

4. neither does L imply GL, nor does GL imply L;

5. if $x$ Lorenz dominates $y$ and $\mu_x \geq \mu_y$, L implies GL.

In addition to AP, PR, T, L, and GL we also tested on tail independence. Tail independence is a consistency requirement: For pairs of distributions with identical parts, only the different parts should matter for distributional preferences, irrespective of the identical parts. Let $x$ and $y$ be two income distribution with identical tails, that is, $x_i = y_i \; \forall \; i = 1, \ldots, j$ and $x_i \neq y_i \; \forall \; i = j+1, \ldots, n$. Let $x = (x_1, \ldots, x_j, x_{j+1}, \ldots, x_n)$ and $y = (x_1, \ldots, x_j, y_{j+1}, \ldots, y_n)$. Then we can state:

**Definition 6 (Tail independence (I))** *Preferences are tail independent if* $x \succsim y$ *or* $y \succsim x$ *for all* $(x_1, \ldots, x_j)$.

Tail independence does not imply any of the other inequality attitudes, nor is it implied by one of them.

# 3 Hypotheses

The evaluation of income distributions is driven by equity and efficiency considerations: The equity component directs attention to the income recipients'

[5]Set $\mu_x = X/n$, then we have $[x_j \geq y_j \; \forall \; j = 1, 2, \ldots, n] \Rightarrow \left[\sum_{i=1}^{j} x_i/n \geq \sum_{i=1}^{j} y_j/n \; \forall \; j = 1, 2, \ldots, n\right]$.

[6]Suppose $x_i = y_i = \alpha > 0 \; \forall \; i = 1, \ldots, n-1$, and $\alpha = y_n < x_n$. Then $x$ Pareto rank dominates $y$, while $y$ Lorenz dominates $x$.

relative income positions. The efficiency component focuses on the income level available in the respective society.

Distributional axioms and dominance relations of income distributions exhibit divers reflections of the equity and the efficiency aspects. Absolute Pareto dominance and Pareto rank dominance compare absolute levels of income and, therefore, are concerned with the efficiency component only. By definition, the transfer principle refers to income distributions having identical mean incomes. Lorenz curves are scale invariant, that is, it is income shares, but not absolute amounts, which matter for the comparison of income distributions. Hence, T and L concern the equity component exclusively. As generalized Lorenz curves are Lorenz curves scaled up by mean income, GL gives credence both to the equity and the efficiency components. Eventually, tail independence lays stress on the decomposability of evaluations of income distributions in the sense that the evaluation is composed of its parts.

Now, the evaluation of income distributions may obviously be governed by the equity and the efficiency components in various ways.[7] Central to our experiment was, however, not the investigation of different subjects' attitudes (that is, the between–subjects analysis), but the change in their inequality attitudes as they switched from their roles as self–interested subjects under a veil of ignorance (see Vickrey, 1945, 1960, 1961; Fleming, 1952; Goodman and Markowitz, 1952; Friedman, 1953; Harsanyi, 1953, 1955; Rawls, 1958, 1971; Strotz, 1958, 1961; Dworkin, 1981; Kolm, 1985, 1998; Dahlby, 1987; Epstein and Segal, 1992; Fleurbaey, 1998; and Beckman et al., 2002) to the social–planner role without any stakes in the income distribution to be finally

[7]Therefore, an experimentalist must not confine subjects' responses to one approach only. This precept is, for example, violated by the experimental treatment of Amiel et al. (1999), who aimed at measuring inequality attitudes but forced their subjects to behave as if they were social welfare maximizers. For a detailed critique see Seidl (2002).

established (see Dalton, 1920; Boulding, 1962; Atkinson, 1970; Blackorby and Donaldson, 1978; Cowell and Kuga, 1981; Cowell, 1985, 1995; Chakravarty, 1990; and Lambert, 1993), that is, the within–subjects analysis.

Under the *self–concern mode*, a subject determines his or her own payoff chances without affecting the other subjects' payoff chances. In contrast to this, under the *social–planner mode*, a subject determines other subjects' payoff chances without affecting her own payoff (which is zero). As the experiment forces subjects to consider the problem of ranking income distributions from two contrary perspectives, we surmise that the "weights" attached to the efficiency aspect on the one hand and the equity aspect on the other hand are contingent upon the experimental mode. This establishes our first hypothesis:

**Hypothesis 1 (Shift of attitudes)** *Subjects' attitudes towards inequality are different under the self–concern mode and under the social–planner mode.*

Our second hypothesis concerns the shift of attitudes with respect to dominance relations:

**Hypothesis 2 (Violations of dominance relations)** *Violations of dominance relations are different between and within treatments.*

When this hypothesis is evidenced, we can test the differences between the dominance relations in terms of acceptance rates. This can be done for either treatment and the results can be qualitatively interpreted.[8]

[8]Note that conclusions about the empirical performance of a particular dominance relationship in comparison with other dominance relationships must be based on relative case numbers. For example, we may observe 4 violations of Lorenz dominance and 5 violations of generalized Lorenz dominance per subject. Thus, from an absolute point of view, GL dominance violations occur more often than L dominance violations. However,

The last hypothesis is concerned with tail independence. Unlike for lotteries, there may be good reasons for a subject to violate tail independence. A rational person will certainly prefer an income of $\tilde{x} = 100,000$ Deutschmarks[9] per year over an income of $\tilde{y} = 90,000$ Deutschmarks. It is less clear, however, that the person prefers income distribution $x = (20,000; 100,000)$ over income distribution $y = (20,000; 90,000)$. Obviously, income is distributed less evenly in $x$ than in $y$. Hence, if the subjects ended up with $20,000$ Deutschmarks, she would feel more *relative deprivation*[10] if the other person had $100,000$ Deutschmarks instead of $90,000$. Likewise, if the subject ended up with $100,000$ Deutschmarks, she would, perhaps, feel more guilt, responsibility, or disutility because of the large degree of inequality in this society than if she had only $90,000$. On the other hand, she may also feel more elation. Therefore, our third hypothesis states:

**Hypothesis 3 (Tail independence)** *Subjects evaluate income distributions in a holistic way, that is, preferences are not tail independent.*

# 4 Experimental Design

Our subjects were 61 students of the University of Kiel, mostly students of economics but also students of the business and law schools. We tested for gender biases but could not evidence any. Subjects participated first in

it may be that there is a total of, say, 6 L dominance relationships and 10 GL dominance relationships, respectively. Then, violations of L (66.7%) occur relatively more often than violations of GL (50%) and, hence, GL would seem to enjoy greater support among the subjects than L.

[9]Our experiment was carried out while the Deutschmark currency was still in force. Therefore, we stick to Deutschmarks in our examples.

[10]Relative deprivation was introduced by Stouffer et al. (1949) and further elaborated by Runciman (1966).

the self–concern treatment and then in the social–planner treatment of the experiment.[11] In both parts, the experiment employed financial incentives. Due to our budget constraint, we kept records of payoffs and continued to make payoffs for each of the two parts of the experiment until a ceiling of 500 Deutschmarks of aggregate payoffs was exceeded. Details are explained below. The written instructions of the experiment are relegated to the Appendix.

At the beginning of the experiment, each subject received an envelope with twelve slips of cardboard together with written instructions, which were also read out aloud to the subjects. The slips of cardboard were coded by symbols to avoid ordering effects triggered by the experimental design. Table 1 displays a synopsis of the stimulus material.[12] It shows on each slip an income distribution consisting of exactly five entries which represented income quintiles and corresponded to reasonable annual incomes in Deutschmarks. As payoffs we used these amounts divided by 2000 (roughly equal to the amount of working hours per year). Using financial incentives represents a major methodological advance in experimental research on distributional problems. In fact, none of the studies mentioned in the Introduction employed financial incentives. Our subjects could earn as much as 125 Deutschmarks, about $60.00, for each draw (with the possibility of being drawn repeatedly in both treatments). Only recently, Beckman et al. (2002)

[11]This sequence of the experimental treatments was aimed at making sure that all subjects at first analyzed the complicated problem of ordering twelve income distributions very carefully. This is best done under conditions of financial incentives for oneself. Having already thoroughly analyzed this challenge, subjects in their role as social planners could avail themselves of an already carefully pondered problem and could concentrate on their different roles.

[12]The ordering and the numbers in Table 1 are only introduced to facilitate reference to the respective income distributions in this paper.

also used financial incentives but their subjects could earn at most \$10.00 in the common version of the experiment (which applied to subjects in the USA, Russia, Taiwan, and China) and \$20.00 to \$25.00 in the high–pay version of their experiment (which was used only for the subjects in China).

**Insert Table 1 about here**

In both parts of the experiment, subjects were required to state complete and strict preference orderings of the twelve income distributions.[13] Subjects were asked to base their decisions on the following two different payoff mechanisms:

Under the self–concern mode, a subject was drawn at random. Then this subject drew a ball from an urn containing 12 balls bearing a 1 (first rank), 11 balls bearing a 2 (second rank), etc., and, finally, 1 ball bearing a 12 (twelfth rank). The number on the ball drawn determined via the subject's rank ordering the respective income distribution to be used for payoff. The more preferred income distributions had thus a higher chance to be chosen for payoff. This procedure was adopted to induce subjects to carefully decide upon their ordering of income distributions. Thereafter, a wheel of fortune with five equally spaced fields was spun to assign the subject to an income quintile. This determined the payoff according to the selected income distribution. Then payoff was immediately effectuated in cash and the next subject was drawn. When aggregate payoffs for this treatment exceeded 500 Deutschmarks, we effectuated the last payoff in full and switched to paying off the social–planner part of the experiment.

[13]Subjects were not allowed to state indifference, since, as in the real world, "social planners" are required to give unequivocal advice and to make clear–cut decisions.

Subjects were thoroughly informed about this procedure. This means that subjects reported their preferences of income distributions from behind a veil of ignorance. Their identity within an income distribution was determined only after they had cast their distributional preferences. Notice, however, that the draw of the wheel of fortune was made in public, so that subjects had no reason to surmise any dependence between the selected income distribution and the probability to end up in any one of the five quintiles.

The social–planner mode followed the same procedure with one important change: When stating their second set of preferences, subjects were instructed to act as impartial social planners who were asked for their advice without any personal involvement. To this end, the experimenters drew a subject who was appointed social planner at random before any payoff was made. The social planner was called to the fore and presented to the audience. His or her ranking then determined the payoffs of all other subjects in the second part of the experiment.

To determine the payoffs, a subject was again drawn at random and drew one ball from the same urn as above but now the social planner's ranking of income distributions was applied instead of the respective subject's ranking. The social planner him– or herself, however, was excluded from any chance to get a payoff. Thus, under the social–planner mode, subjects were aware that, when their ordering of income distributions would ever become effective, they themselves would forgo any payoff in this part of the experiment. However, when they were not drawn to become the social planner, and could thus participate in the payoffs, their ordering of income distributions becomes meaningless for the determination of payoffs. This procedure aimed at inducing subjects to feel really as social planners. They

compiled their orderings of income distributions without any own stakes in the outcomes.

We chose this experimental treatment to induce subjects to behave like outside social planners (as judges, politicians, researchers, consultants, national–accounts statisticians, executives of an international organization). This mode deprived them of any stakes in the outcome but instead appeals on their perception of fair income distributions for the rest of the community. The exclusion from receiving payoffs was not the only characteristic of this treatment. To compensate for the loss of payoffs and, at the same time, maintaining interest in a careful analysis of the problem, we introduced some kind of social pressure by calling the social planner to the fore and presenting him or her to the audience. Thereby all subjects had sufficient incentives to propose orderings of the twelve income distributions which they would consider as being the fairest ones.[14]

Section 2 provided a list of dominance relationships surveyed in this paper. Table 2 shows the dominance relationships of our experimental design. As can be gathered from this table, our experimental design contains 15 Pareto rank dominance relationships, 4 of which are also absolute Pareto dominance relationships (these are underlined in Table 2), 17 cases of transfer dominance relationships, 53 Lorenz dominance relationships and 41 generalized Lorenz dominance relationships.[15] The total number of the respective relationships are again listed in the second column of Table 4 below.

[14]Of course, one could think of a third treatment, a mixed mode, under which the social planner gets paid by the other subjects according to their satisfaction with her decisions. In our experiment, we focussed on the two pure cases.

[15]Note that, if $x$ Lorenz dominates $y$ and $\mu_x \geq \mu_y$, L also implies GL. These 28 correspondences between L and GL are framed in Table 2. In the remaining 25 and 13 cases, respectively, only one of both dominance relationships applies.

**Insert Table 2 about here**

# 5 Results

## 5.1 Shift of Attitudes

Before analyzing dominance relationships, we cast a look at the aggregate preference ranks of the alternatives. In order to do so, we use the mean and median Borda counts of all 12 alternatives for both treatments of the experiment. As there are 12 stimuli, the Borda count of income distribution $a$ in treatment $t$ by subject $s$ is given by $B^t_{a,s} := 12 - r^t_{s,a}$, where $r^t_{s,a}$ denotes the rank place (from 1 to 12) assigned to alternative $a$ under treatment $t = \{\text{self–concern}, \text{social planner}\}$ by subject $s$. Table 3 lists the mean incomes, standard deviations, and mean and median Borda counts of the 12 income distributions used as stimuli.

If there was no treatment effect, that is, if there was no shift of attitudes caused by proceeding to the social–planner mode, the Borda counts of a given income distribution should be the same under either mode. Hence, we base our test on a shift of attitudes on the differences of the individual Borda counts. Since the Kolmogorov–Smirnov test rejects normality of these differences for all income distributions, we do not report $t$ tests here. Instead, we employ a nonparametric Wilcoxon test, that is, the null hypothesis is given by $\mathcal{H}_0 \ : \ M = 0$, where $M$ denotes the median of the individual differences of the Borda counts between the self–concern and the social–planner modes. The last two columns of Table 2 give the $Z$ statistic (we use the normal

approximation since $M = 0$ under the null hypothesis and $n > 20$) and the significance level ($p$) of the Wilcoxon test.

**Insert Table 3 about here**

Income distributions 8 and 9 were ranked highest under the self–concern mode as well as the social–planner mode, yet we observe a significant loss of attractiveness ($p \leq .01$) under the latter mode. This result was to be expected since distributions 8 and 9 stand out for a relatively large mean income, a moderate standard deviation, and the largest minimum income. Income distribution 12 which not only tempted with a 40% chance of winning 125 Deutschmarks but also threatened with a possible payoff of zero was ranked on the third place under the self–concern mode but lost distinctly when switching to the social–planner mode ($p \leq .10$). The relatively large gap between mean and median Borda count of alternative 12—it also exhibits the largest standard errors (SE)—shows how controversial this income distributions was among our subjects. The big winners under the social–planner mode were alternatives 1 and 3 to 5, that is, the alternatives with moderate mean and low standard deviation ($p \leq .05$ and $p \leq .01$, respectively). Notice that the equal income distribution 1 gained particular support under the social–planner mode. Its mean Borda count increased by about 1.3 and its median Borda count increased by 2. Income distribution 2, which enjoyed the highest preference among the distributions with a mean of 60,000 Deutschmarks in the self–concern mode, increased, but only insignificantly, under the social–planner mode.[16]

[16]One might object to the cardinalization of subjects' preferences by the Borda method. However, a simple sign test which, in contrast to the Wilcoxon test, manages with ordinal

The analysis of subjects' preferences as measured by the Borda method, demonstrates a shift in their role attitudes under different treatments. This supports Hypothesis 1.

## 5.2 Violations of Dominance Relationships

Section 5.1 has already indicated that the direction of the shift of subjects' preferences as measured by the Borda counts points in the direction of Hypothesis 2: There are less violations of AP and PR and more violations of T and L in the self–concern mode than in the social–planner mode. For GL, the efficiency component overcompensates the equity component, that is, there are less violations in the self–concern mode than in the social–planner mode. Table 4 provides the empirical results.

**Insert Table 4 about here**

The first column of Table 4 gives a breakdown of the dominance relations as listed in detail in Table 2. The second column contains the number of the respective cases. Columns 3 to 6 show the average and the median number of violations of the respective dominance relations per subject under both treatments. The next three columns of the table give the results of two–tailed paired–sample $t$ tests on the equality of two means, Kolmogorov–Smirnov tests on normality of the distribution of the mean differences, and nonparametric Wilcoxon tests. Standard errors and significance levels figure in the rows beneath. Again, the null hypothesis is given by $\mathcal{H}_0 \ : \ \mu = 0$

data, provides us with the same results except for income distributions 1 and 12. For these income distributions, a sign test rejects the null hypothesis ($p \leq .10$) only if we assume a composite null hypothesis, that is, $\mathcal{H}_0 \ : \ M \leq 0$.

(t test) and $\mathcal{H}_0 \ : \ M = 0$ (Wilcoxon test), respectively. $\mu$ and $M$ denote the mean and the median of the difference between the absolute number of violations of dominance relations $d_1$, $v^t_{d_1,s}$, and $d_2$, $v^t_{d_2,s}$, by subject $s$ under treatment $t$. That is, under the null hypothesis, we assume that the shift of attitudes between the self–concern mode and the social–planner mode did not affect the number of violations of a particular dominance relation.

Concerning Pareto dominance, Table 4 shows a significant increase of the average number of violations of both AP and PR ($p \leq .01$). These violations, however, concentrated on less than 50% of the sample. Since normality was strongly rejected by the Kolmogorov–Smirnov test, we not only conducted t tests but also confirmed our results by nonparametric Wilcoxon tests. Thus, the shift away from efficiency considerations when moving to the social–planner mode is again reflected in the number of violations of AP and PR.

Table 4 reports only a slight and insignificant decrease of violations of transfer dominance between both modes. Transfer dominance captures only the equity aspect of income distributions with equal mean incomes. On the one hand, akin to the results in Table 3, income distribution 1 improves distinctly with respect to both its Borda count and its relative position to income distributions 2 to 7. As income distribution 1 transfer dominates all other income distributions with a mean income of 60,000 Deutschmarks, this exhibits a tendency towards less violations of T. In fact, the number of violations of T between income distribution 1 and income distributions 2 to 7 decreases (insignificantly) from 2.492 to 2.180 ($Z = -.861$, $p = .389$, Wilcoxon test). Likewise, income distribution 5 improves relatively, accompanied by a decrease of violations of T between distributions 5 and 3, 4, 6, and 7, respectively, from 1.492 to 1.372 ($Z = -.609$, $p = .542$, Wilcoxon test). On the other hand, income distribution 2, which leads the group of

income distributions with equal mean incomes under the self–concern mode, drops back to the third place under the social–planner mode. Hence, the number of violations of transfer dominance between 2 and 3, 4, and 6 rose slightly from 1.100 to 1.164 ($Z = . - 367$, $p = .714$, Wilcoxon test).

While the number of violations of Lorenz dominance decreased slightly ($p \leq 10\%$), violations of generalized Lorenz dominance increased somewhat ($p \leq 10\%$). Remember that L captures solely the equity aspect of income distributions; GL additionally takes into account the efficiency aspect via mean income. In order to interpret these results, we have to split L and GL into different regions: First, there are 28 cases where L and GL intersect. Since 17 of these cases are implied by T, it is not too surprising that the hypothesis that the number of violations stays put cannot be rejected within this region. Second, in the 25 cases in which Lorenz dominance applied exclusively, we found a significant decrease of the number violations of L. Third, in the 13 cases in which GL applied exclusively, a significant increase of violations occurred (though the absolute number of violations was relatively low).

The pronounced decrease of the number of violations of L is due to the greater importance attached to equity considerations under the social–planner mode. The situation is different for GL: Consider, for example, income distributions 8 and 1 in isolation.[17] Distribution 8 generalized Lorenz dominates distribution 1 because its higher mean income (94,000 vs. 60,000 Deutschmarks, compare Table 2) can compensate for its greater degree of inequality (standard deviations: 23,022 vs. 0, compare Table 2).[18] Under the

[17]We do not list the number of violations for every dominance relationship separately here, since such a table would go out of the ordinary. The data is, however, available from the authors on request.

[18]Note that none of the generalized Lorenz dominance relationships was in such a way

self–concern mode, the vast majority of subjects would agree with this view, as we ascertained only 2 violations of GL with respect to these two income distributions. Under the social–planner mode, however, the picture changed dramatically, as no less than 20 subjects now preferred income distribution 1 over the dominating income distribution 8! Thus, under the social–planner mode, subjects place greater weight on the equity component.

To summarize, the number of AP, PR, and GL violations increases significantly under the social–planer mode. In contrast, the number of L violations decreases significantly, in particular, for income distributions with unequal mean income. No significant change can be observed for T. We attribute these observations to the shift of attitudes between both treatments, that is, more weight is given to equity considerations under the social planner mode. Hence, the first part of Hypothesis 2 is supported by our data, except for T.

## 5.3 Structural Analysis: Acceptance Rates of Dominance Relations

The preceding section has evidenced that we observe less violations of AP, PR and GL and more violations of T and L in the self–concern mode than in the social–planner mode. Although this sets the stage for a bedrock characterization of subjects' behavior with respect to dominance relations, it provokes the question of whether subjects behave similarly or dissimilarly within these two groups of dominance relations under the two experimental treatments. The results of our test can then be qualitatively interpreted.

For this reason we compare the relative importance of dominance relations in terms of acceptance rates $r$. We define $r^t_{d,s} := 1 - v^t_{d,s}/m_d$, where $r^t_{d,s} \in$

that an income distribution exhibiting a lower mean income dominated another income distribution.

$[0, 1]$ denotes the acceptance rate of dominance relation $d$ by subject $s$ under treatment $t$, $v^t_{d,s}$ denotes the absolute number of violations of dominance relation $d$ observed for subject $s$ under treatment $t$, and $m_d$ denotes the total number of dominance relationships of type $d$ in the stimulus material. Since the number of violations actually observed is now normalized by the number of violations possible ($m_d$), this proceeding allows comparisons of the relative importance of the different dominance concepts.

Table 5 presents the respective results. Its entries give, for each dominance relation, the mean, the standard error, and the median of $r$. We report four pairwise tests, where the null hypothesis is always that the dominance relations involved in the comparison enjoy the same acceptance rates, that is, $\mathcal{H}_0 \ : \ M = 0$, where $M$ is the median of the difference of the individual acceptance rates of the two respective dominance relations.

**Insert Table 5 about here**

First, we consider absolute and rank Pareto dominance. Under the self–concern mode, violations of Pareto dominance play only a minor part, as subjects violated on average only about 5 or 6 percent of all Pareto dominance relationships. A Wilcoxon test cannot reject the null hypothesis that both types of Pareto dominance enjoy the same acceptance rates ($Z = -.595$, $p = .522$). In the previous paragraphs, we already demonstrated that violations of Pareto dominance increased significantly when subjects switched to the social–planner mode. Table 5 points out an additional effect: Since AP dominance relationships are more transparent than PR dominance relationships, the increase of AP violations was less pronounced than the increase of PR violations such that the acceptance rate of AP is higher now ($Z = -2.056$,

$p = .040$).

Second, a comparison between PR and GL shows that under the first treatment GL violations occurred significantly more often than violations of PR ($Z = -5.633$, $p = .000$) while under the social–planner mode both dominance relations enjoyed the same acceptance rates ($Z = -.779$, $p = .436$). Since PR implies GL this means that, under the self–concern mode, GL violations concentrated on the 26 GL cases which did not involve PR relationships as well. This result was to be expected, since PR represents the efficiency aspect of income distributions, which received more attention in the first treatment.

Third, even though the shift of attitudes between both modes increased the acceptance rate of Lorenz dominance from about 55% to 61%, it was still less accepted than generalized Lorenz dominance (76% vs. 69%). This is confirmed by Wilcoxon tests (self–concern mode: $Z = -6.289$, $p = .000$; social–planner mode: $Z = -2.676$, $p = .007$).

Fourth, we observe a robust violation of the transfer principle in between 39% and 35% of cases, a figure which has also been evidenced in earlier research of Amiel and Cowell (1992, 1994a, 1994b, 1998, 1999a, 1999b, 2000), Ballano and Ruiz–Castillo (1993)[19], Harrison and Seidl (1994a,b), and Bernasconi (2002). Since T and L intersect only partly and the acceptance rates of T are larger than the acceptance rates of L (self–concern mode: $Z = -2.510$, $p = .012$; social–planner mode: $Z = -1.925$, $p = .054$), we can conclude from this that violations of Lorenz dominance occur more often if $x$ Lorenz dominates $y$ but $\mu_x < \mu_y$, that is, if there is a trade–off between equity and efficiency. This is more pronounced for the self–concern mode

[19]Ballano and Ruiz–Castillo (1993), pp. 245–7, observed only about half of this order of violations of the transfer principle.

than for the social–planner mode. Likewise, T and GL intersect only partly. However, the acceptance of T is significantly greater than GL only under the self–concern mode (self–concern mode: $Z = -5.799$, $p = .000$; social–planner mode: $Z = -1.430$, $p = .153$).

With respect to the second part of Hypothesis 2, we found that under the self–concern mode only the hypothesis that the acceptance rates of AP and PR are unequal has to be rejected. Under the social–planner mode, the hypotheses that the acceptance rates of PR and GL, and T and GL, respectively, are unequal have to be rejected. Summarizing, we observe the following rank orders of the dominance relations in terms of acceptance rates: AP $\sim$ PR $\succ$ GL $\succ$ T $\succ$ L under the self–concern mode and AP $\succ$ PR $\sim$ GL $\sim$ T $\succ$ L under the social–planer mode.[20]

## 5.4 Tail Independence

Finally, we test for tail independence. Tail independence concerns income distributions 8 to 11. The first two entries of income distributions 8 and 9 are the same, and the first two entries of income distributions 10 and 11 are the same. The last three entries are the same for income distributions 8 and 10, and 9 and 11, respectively. Thus, tail independence requires that when a subject evaluates 8 higher (lower) than 9, then she should also evaluate 10 higher (lower) than 11.[21]

[20]Concerning the indifference between $PR$ and $T$ in the second treatment, note that the null hypothesis of equality of the acceptance rates of PR and T could not be rejected ($Z = -1.403$, $p = .161$).

[21]Note that tail independence would also require that when a subject evaluates 8 higher (lower) than 10 she should also evaluate 9 higher (lower) than 11. However, since income distribution 8 Pareto rank dominates 10 and income distribution 9 Pareto rank dominates 11, this case will not be considered in the following.

**Insert Table 6 about here**

Table 6 informs about violations of tail independence. A sign test did not reject the null hypothesis that the subjects' performance was the same under both modes. With respect to the first case, we found a large number of violations of tail independence. Violations of the type I ($\{8 \succ 9, 10 \prec 11\}$) were almost as frequent as violations of type II ($\{8 \prec 9, 10 \succ 11\}$), namely 25 type I and 22 type II violations.

Let $V$ denote the number of violations of tail independence. In order to formally test on tail dependence as hypothesized, we assume that tail independence is true under the null hypothesis, that is, $\mathcal{H}_0 \ : \ V = 0$ and reject the null hypothesis if $V \geq v$. $v$ is the critical value obtained from a binomial distribution with parameter $q$, where $q$ denotes the error probability that a subject unintentionally violates tail independence. Since fixing $q$ to a specific value is arbitrary, we choose $q = \{.1, .2, .5\}$. Note that $q = .5$ would mean that subjects pay no attention at all at tail independence, as their choices were governed by pure chance, while the former two values assume that subjects obey tail independence with individual error rates of 10 and 20 percent, respectively.

Eventually, we set the significance level of the test to $p \leq .05$, which yields $v_{q=.1} = 11$, $v_{q=.2} = .18$, and $v_{q=.5} = 38$. Since we have $V = 27$ under the self–concern mode and $V = 22$ under the social planner mode, the null hypothesis has to be rejected for $q = .1$ and $q = .2$ but not for pure chance ($q = .5$). This means that tail independence is violated under the assumption of reasonable error rates.

Can there be made a case in favor of violation of tail independence for

income distributions? We think that violations of tail independence are, unlike for the lottery case, quite understandable for the evaluation of income distributions. Some subjects may find (100,000, 110,000, 120,000) to be more equally distributed than (70,000, 90,000 180,000). Now, imagine two different cases of a sudden immigration of two thirds of the former population, either have–nots (disposing of an income of 15,000 Deutschmarks each per year), or moderately wealthy people (disposing of an income of 70,000 Deutschmarks each per year). There may well exist subjects among the former group who perceive 9 to be more equitably distributed than 8 [perhaps because of three entries of 70,000], yet 10 to be more equitably distributed than 11. This is because (10) and (11) suggest themselves as ambivalent societies: 40% of have–nots are either combined with 60% homogeneously wealthy people, or with a 40% middle class of moderately wealthy people and a 20% stratum of rather rich persons. It is perfectly understandable that a subject might consider (10) as more equitable than (11): As the 40% poor cannot be avoided in either case, then at least the rest should be distributed more equally.

Violation of tail independence seems to indicate that some subjects perceive income distributions in a holistic way, which does not boost support for the decomposability property.

# 6 Conclusions

Income distributions are not amenable to be dealt with in terms of allocation efficiency. Eminent scholars, such as Lorenz (1905), Pareto (1906), Pigou (1912), and Shorrocks (1983) have, therefore, proposed dominance relations to rank income distributions in terms of partial orderings. Although these dominance relations are implied by more elementary distributional ax-

ioms, the composite relationships have to be tested directly in experimental research, unless we assume that subjects function like perfect computers. Moreover, we have to allow that subjects' behavior may be contingent on their roles which they occupy when stating their preferences on income distributions. This aspect is indeed the main focus of the present paper.

Using an experiment with material incentives, this paper investigates the violation of composite dominance relationships, viz. absolute Pareto dominance, Pareto rank dominance, transfer dominance, Lorenz dominance, and generalized Lorenz dominance. Moreover, we test tail independence. The experiment consists of two treatments, a self–concern mode (in which each subject expects payoffs according to her own choices), and a social–planner mode (in which subjects form their preferences without any chance of receiving payoffs when they became effective).

Using the Borda method to measure subjects' preferences for income distributions, we show major behavioral shifts between the self–concern and the social–planner modes. Income distributions with lower levels of income but more equality receive higher scores under the social–planner mode than under the self–concern mode. The opposite is observed for distributions with high levels of income and less income inequality. A more detailed analysis allows identification of the respective behavioral shifts for groups of dominance relations. There are less violations of the two Pareto dominance relations and of generalized Lorenz dominance and more violations of Lorenz dominance and of transfer dominance under the self–concern mode than under the social–planner mode. Probing similarity of behavior within the two dichotomous groups of dominance relations, we observe that behavior is more homogeneous under the self–concern mode than under the social–planner mode. Finally we find that tail independence is widely rejected, which suggests that income

distributions are perceived in a holistic way rather than as pieced together from independent components.

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# Appendix: Instructions

At the beginning of the experiment, two closed envelopes containing 12 slips of cardboard (shown in Table 1) were handed over to the subjects. Furthermore, an urn containing 78 balls (numbered as described in Section 4) and a wheel of fortune with five equally likely sectors numbered from 1 to 5 were placed on a table in front of the subjects. The subjects received a sheet of paper with instructions. The instructions were also read out aloud, and the subjects were given some time to study them on their own, and to ask questions.

> *Dear participant!*
>
> *We would like to thank you for participating in our experiment.*
>
> *In this experiment, you will be asked to rank different income distributions according to their desirability. There will be four different setups. When all decisions have been made, we will draw—for each setup separately—participants randomly and pay them off according to their decisions until the sum of payoffs exceeds a budget of 500 Deutschmarks in each setup.*
>
> *For a participant drawn, the payoff is determined as follows: Assume that you ranked $N$ different income distributions. Now, a ball is drawn from an urn which contains $N$ balls with number 1, $N-1$ balls with number 2, $N-2$ balls with number 3, and so on, and 1 ball with number $N$. Your payoff is then determined by the income distribution for which your ranking and the number of the ball drawn correspond. Further details depend on the setup and will be explained on separate questionnaires.*

*Please mark each questionnaire with your name, and mark with a cross whether your are male or female.*

After reading out these instructions, the first questionnaire was handed over to the participants and, again, read out aloud to the subjects.

*In the envelope, you will find 12 income distributions. The income recipients are split into 5 equally sized groups, each amounting to 20% of the population. Please, rank the income distributions (annual net incomes in Deutschmarks) according to your preferences. If you are drawn for receiving a payoff, in the first step, you will be assigned to one of the five income groups with a 20% probability each. In the second step, an income distribution will be drawn randomly and you receive* 1/2000 *of the income corresponding to your income group. Enter your preference order of the income distributions using the symbols displayed on the slips of cardboard in table below.*

The second treatment of the experiment was introduced by the following questionnaire:

*Consider the 12 income distributions again, where the income recipients are split into 5 equally sized groups of 20% of the population. Please, rank the income distributions according to your preferences. Note, however, that one participant is drawn randomly at the end of the experiment and becomes a social planner. The name of the social planner and his or her decisions will be made public. Now, the rank order of the social planner determines the probability of one of the income distributions being chosen for the whole group of participants. If you are drawn for*

*receiving a payoff, in the first step, you will be assigned to one of the five income groups with a 20% probability each. In the second step, an income distribution will be drawn according to the social planner's preferences and you receive* 1/2000 *of the income corresponding to your income group. The social planner is excluded from getting any payoff. Enter your preference order of the income distributions using the symbols displayed on the slips of cardboard in the table below.*

# Tables

**Table 1** Stimulus material of the experiment

| No. | Symbol | Name | Income distribution |
|---|---|---|---|
| 1 | □ | square | (60,000 60,000 60,000 60,000 60,000) |
| 2 | ⋄ | diamond | (50,000 55,000 60,000 65,000 70,000) |
| 3 | ◯ | circle | (40,000 50,000 60,000 70,000 80,000) |
| 4 | + | cross | (40,000 40,000 60,000 80,000 80,000) |
| 5 | ⋈ | bowtie | (40,000 60,000 60,000 60,000 80,000) |
| 6 | 𝕏 | swords | (10,000 20,000 60,000 100,000 110,000) |
| 7 | △ | triangle | (10,000 60,000 60,000 60,000 110,000) |
| 8 | ▽ | giveaway | (70,000 70,000 100,000 110,000 120,000) |
| 9 | — | horline | (70,000 70,000 70,000 90,000 180,000) |
| 10 | \| | verline | (15,000 15,000 100,000 110,000 120,000) |
| 11 | ⧖ | sandglas | (15,000 15,000 70,000 90,000 180,000) |
| 12 | ⊠ | crossbox | (0 60,000 80,000 250,000 250,000) |

**Table 2** Dominance structure

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 | 94,000 | 96,000 | 72,000 | 74,000 | 128,000 |
| | 0 | 7,906 | 15,811 | 20,000 | 14,142 | 45,277 | 35,355 | 23,022 | 47,749 | 52,512 | 67,952 | 115,195 |
| 1 | — | T,L,GL | T,L,GL | T,L,GL | T,L,GL | T,L,GL | T,L,GL | L | L | L | L | L |
| 2 | | — | T,L,GL | T,L,GL | L,GL | T,L,GL | L,GL | L | L | L | L | L |
| 3 | | | — | T,L,GL | | T,L,GL | L,GL | | | L | L | L |
| 4 | | | | — | | T,L,GL | L,GL | | | L | L | L |
| 5 | | | T,L,GL | T,L,GL | — | T,L,GL | T,L,GL | | | L | L | L |
| 6 | | | | | | — | | | | | | L |
| 7 | | | | | | T,L,GL | — | | | | | L |
| 8 | PR,GL | PR,GL | PR,L,GL | PR,L,GL | PR,GL | PR,L,GL | PR,L,GL | — | L | PR,L,GL | L,GL | L |
| 9 | PR,GL | PR,GL | PR,GL | PR,GL | PR,GL | GL | PR,GL | | — | GL | PR,L,GL | L |
| 10 | | | | | | GL | | | | — | L | |
| 11 | | | | | | GL | | | | | — | |
| 12 | | | | | | | | | | | | — |

*Table note.* Alternative (row) dominates alternative (column) by criterion $k$, where $k$ = PR (Pareto rank dominance), T (transfer principle), L (Lorenz dominance), GL (generalized Lorenz dominance); if PR is underlined, AP (absolute Pareto dominance) applies too. The framed areas mean that L implies GL. The figures in the head of the table give the means and standard deviations of the respective income distributions.

**Table 3** Average and median Borda counts of the income distributions

| | | | Borda count | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Standard | Self–concern | | | Social planner | | | Wilcoxon test | |
| No. | income | deviation | Mean | SE | Median | Mean | SE | Median | $Z$ | $p$ |
| 1 | 60,000 | 0 | 5.049 | .433 | 5 | 6.377 | .442 | 7 | -2.393[a] | .017 |
| 2 | 60,000 | 7,906 | 5.344 | .381 | 6 | 5.721 | .372 | 6 | -.554[a] | .580 |
| 3 | 60,000 | 15,811 | 4.393 | .304 | 5 | 5.590 | .313 | 6 | -2.626[a] | .009 |
| 4 | 60,000 | 20,000 | 4.213 | .267 | 4 | 5.230 | .291 | 5 | -2.727[a] | .006 |
| 5 | 60,000 | 14,142 | 4.705 | .284 | 5 | 5.918 | .342 | 6 | -2.643[a] | .008 |
| 6 | 60,000 | 45,277 | 2.984 | .382 | 2 | 2.967 | .416 | 2 | -.188[b] | .851 |
| 7 | 60,000 | 35,355 | 3.541 | .360 | 3 | 4.246 | .432 | 3 | -1.040[a] | .298 |
| 8 | 94,000 | 23,022 | 9.525 | .210 | 10 | 7.853 | .447 | 9 | -3.276[b] | .001 |
| 9 | 96,000 | 47,749 | 9.410 | .251 | 10 | 7.656 | .458 | 10 | -3.247[b] | .001 |
| 10 | 74,000 | 52,512 | 4.934 | .335 | 4 | 4.541 | .349 | 4 | -1.256[b] | .209 |
| 11 | 74,000 | 67,952 | 4.885 | .418 | 5 | 4.410 | .359 | 4 | -.841[b] | .400 |
| 12 | 128,000 | 115,195 | 7.016 | .576 | 9 | 5.492 | .612 | 7 | -1.955[b] | .051 |

*Table note.* $n = 61$. SE=standard error of the mean.

[a] $Z$ statistic based on negative ranks.

[b] $Z$ statistic based on positive ranks.

**Table 4** Violations of dominance relations

| Dominance | | Self–concern | | Social planner | | $t^b$ | KS-$Z^c$ | $Z^d$ |
|---|---|---|---|---|---|---|---|---|
| Relation | Max | Mean | Median | Mean | Median | $p$ | $p$ | $p$ |
| AP | 4 | .213 | 0 | 1.230 | 0 | -5.038 | 3.095 | -4.095[e] |
| | | .102 | | .219 | | .000 | .000 | .000 |
| PR | 15 | .852 | 0 | 4.083 | 0 | -4.699 | 2.590 | -4.098[e] |
| | | .335 | | .712 | | .000 | .000 | .000 |
| T | 17 | 6.705 | 5 | 5.951 | 4 | .979 | 1.473 | -.789[f] |
| | | .722 | | .708 | | .332 | .026 | .430 |
| L | 53 | 24.049 | 22 | 20.787 | 19 | 1.535 | 1.269 | -1.780[f] |
| | | 1.669 | | 1.607 | | .130 | .080 | .075 |
| GL | 41 | 9.820 | 8 | 12.721 | 12 | -1.940 | 1.424 | -1.839[e] |
| | | 1.082 | | 1.432 | | .057 | .035 | .066 |
| L ∩ GL | 28 | 8.754 | 7 | 9.098 | 6 | -.306 | 1.339 | -.269[f] |
| | | .947 | | 1.041 | | .791 | .055 | .788 |
| L \ GL | 25 | 15.295 | 16 | 11.689 | 12 | 2.988 | 1.202 | -3.009[f] |
| | | .911 | | .977 | | .004 | .111 | .003 |
| GL \ L | 13 | 1.066 | 0 | 3.623 | 0 | -4.250 | 2.358 | -3.609[e] |
| | | .315 | | .609 | | .000 | .000 | .000 |

*Table note.* $n = 61$.

[a]First row: means; second row: standard errors.

[b]Two–tailed paired–sample $t$ test on equality of two means.

[c]Kolmogorov–Smirnov test on normality of the mean differences.

[d]Wilcoxon test.

[e]$Z$ statistic based on negative ranks.

[f]$Z$ statistic based on positive ranks.

**Table 5** Acceptance rates of dominance relations

| | Self–concern | | | Social planner | | |
|---|---|---|---|---|---|---|
| | Mean | SE | Median | Mean | SE | Median |
| AP | .942 | .022 | 1.000 | .741 | .046 | 1.000 |
| PR | .947 | .026 | 1.000 | .693 | .055 | 1.000 |
| T | .606 | .042 | .706 | .650 | .042 | .765 |
| L | .546 | .031 | .585 | .608 | .030 | .642 |
| GL | .761 | .026 | .805 | .690 | .035 | .707 |

**Table 6** Violations of tail independence

| | # | % | $p^a$ |
|---|---|---|---|
| Self–concern | 27 | 44.3 | .265 |
| Social planner | 20 | 32.3 | |

[a]Exact significance level of a sign test.