KU LEUVEN

CENTER FOR ECONOMIC STUDIES

DISCUSSION PAPER SERIES
DPS14.22
JULY 2014

Measuring the willingness-to-pay for others' consumption: an application to joint decisions of children

Sabrina BRUYNEEL, Laurens CHERCHYE, Sam COSAERT, Bram DE ROCK, Siegfried DEWITTE

Public Economics

Faculty of Economics
And Business

Measuring the willingness-to-pay for others' consumption: An application to joint decisions of children.*

Sabrina Bruyneel† Laurens Cherchye‡ Sam Cosaert§

Bram De Rock¶ Siegfried Dewitte‖

January 28, 2016

Abstract

We propose a method to quantify other-regarding preferences in group decisions. Our method is based on revealed preference theory. It measures willingness-to-pay for others' consumption and willingness-to-pay for equality in consumption by evaluating consumption externalities in monetary terms. We introduce an altruism parameter and an inequality aversion parameter. Each parameter defines a continuum of models characterized by varying degrees of externalities. We use our method to analyze decisions made by dyads of children in an experimental setting. We find that children's decisions are particularly characterized by varying levels of altruism. We relate this heterogeneity across children to age, gender and the degree of friendship in dyads.

JEL Classification: D11, D12, C14

Keywords: consumption externalities, altruism, inequality aversion, revealed preferences, children's consumption

---

*This research has been funded by the Fund for Scientific Research-Flanders (FWO), Belgium. We are grateful to the editor Rosa Matzkin and three anonymous referees. We also thank Georg Kirchsteiger, Ian Crawford, Mark Dean, Geert Dhaene and Frederic Vermeulen for useful discussion.

†BEE Center for Behavioral Engineering Research, University of Leuven, Naamsestraat 69, B-3000 Leuven, Belgium. E-mail: Sabrina.Bruyneel@kuleuven.be.

‡Center for Economic Studies, University of Leuven. E. Sabbelaan 53, B-8500 Kortrijk, Belgium. E-mail: laurens.cherchye@kuleuven.be. Laurens Cherchye gratefully acknowledges the European Research Council (ERC) for his Consolidator Grant 614221 and the Research Fund K.U.Leuven for the grant STRT1/08/004.

§Center for Economic Studies, University of Leuven. E. Sabbelaan 53, B-8500 Kortrijk, Belgium. E-mail: sam.cosaert@kuleuven.be.

¶ECARES, Université Libre de Bruxelles. Avenue F. D. Roosevelt 50, CP 114, B-1050 Brussels, Belgium. E-mail: bderock@ulb.ac.be. Bram De Rock gratefully acknowledges Belspo for supporting this research.

‖BEE Center for Behavioral Engineering Research, University of Leuven, Naamsestraat 69, B-3000 Leuven, Belgium. E-mail: Siegfried.Dewitte@kuleuven.be.

1 Introduction

This study is motivated by Rabin (2013)'s "PEEMs" (Portable Extensions of Existing Models) research program, which aims at developing tractable refinements of existing economic models that integrate psychological insights. The program encourages the design of new models that encompass a basic, pre-existing model at one particular parameter value, while other values for the same parameter imply modifications of the basic model. Rabin recommends the modeling of social preferences as a prime PEEMish application area. The literature has produced a mass of experimental evidence that rejects the standard model of purely selfish behavior. However, Rabin argues that the replacing models with social preferences typically fail to derive plausible economic implications beyond specific laboratory environments. This indicates a need for analytical tools to handle non-selfish preferences in more general settings.

In the current paper, we apply Rabin's PEEM program to two main types of social preferences (other types of social preferences are discussed in the concluding section). We consider the role of altruism and inequality aversion in group consumption behavior. In the case of group consumption, these extensions imply that individuals are not purely selfish, but willing to pay for *others' consumption* and for *equality of consumption*. We introduce a methodology that allows us to measure this revealed willingness-to-pay in monetary terms. In line with our above motivation, the methodology to deal with altruistic behavior associates an altruism parameter value of zero with the standard model of purely selfish consumers, but also includes a whole range of other models (with varying levels of altruism) for higher parameter values. Similarly, the methodology to deal with inequality aversion associates an inequality aversion parameter value of zero with the selfish model, but also encompasses a whole range of other models (with varying preferences for equality) for higher parameter values. In this way, we consider two distinct generalizations – with social preferences – of the selfish consumption model.[1]

We use our methodology to analyze the consumption choices made by dyads (i.e. two-person groups) of children in a tailored experiment. As we discuss in detail further on, there is quite some debate in the literature on how (non-)selfish behavior corresponds to specific child characteristics. In our application, we first investigate to what extent children's consumption decisions are effectively characterized by externalities (i.e. altruism or inequality aversion). It will turn out that particularly altruism helps to rationalize the observed consumption behavior. Subsequently, we examine how age, gender and friendship between dyad members relate to revealed altruism, so adding useful empirical input to the existing debate. At a more general level, this application shows the practical usefulness of our method to analyze the presence and determinants of prosocial (i.e. non-selfish) consumer behavior.

The remainder of this introductory section specifies our research question. We also introduce the basic framework of our measurement methodology, and motivate our empirical application.

[1]For clarity of exposition, we consider the altruism and inequality aversion models separately in the main text of this paper. We discuss the "general" model that combines altruistic preferences with inequality aversion in the Appendix (A, B and D).

Prosocial behavior. Consumer preferences are characterized by externalities when individual utilities depend not only on the own material consumption but also on the others' consumption. In the empirical literature there is plenty of evidence that economic agents often act non-selfishly. For example, in social dilemma games, experimenters find that subjects cooperate even in one-shot games, when the only rational choice under selfishness is to defect; in ultimatum games subjects offer a substantial amount of tokens to their counter-parties; in dictator games the dictators often share a fraction of their budget. The literature has suggested many alternative explanations for these phenomena, including altruism (Andreoni and Miller (2002), Fisman et al. (2007) and Cox et al. (2008)), inequality aversion (Fehr and Schmidt (1999) and Bolton and Ockenfels (2000)), reciprocity (Charness and Rabin (2002)) and concerns for efficiency and the pay-offs of the least well off (Charness and Rabin (2002) and Engelmann and Strobel (2004)).

In the current paper, our focus is on two types of social preferences that are typically related to the notion of prosocial behavior: altruism and inequality aversion. We aim at measuring the degree of prosocial behavior in a general setting of group consumption. To do so, we assume a structural model of rational group behavior, which allows for consumption externalities, and which enables us to quantify the monetary value of externalities as individuals' willingness-to-pay for others' consumption and individuals' willingness-to-pay for equality of consumption. In particular, we can check how large this willingness-to-pay needs to be in order to rationalize the observed group consumption decisions. This methodology has several useful applications. For example, it can be used to quantify the extent to which models with selfish consumers are "wrong" and, therefore, may lead to biased conclusions. Also, as we will illustrate in our own application, it allows us to relate the degree of prosocial behavior to specific consumer characteristics, which in turn leads to identifying which type of consumer is generally more or less selfish.

At this point, we want to remark that the literature studying joint or interdependent decision making has tended to merge the two motives (altruism and inequality aversion). Illustrative is that the most influential measurement method in psychology, the Social Value Orientation explicitly merges the two motives into the so-called "prosocial type" (van Lange (1999)). The small proportion of pure types (altruists and inequality averse) that recent research in psychology (Millet and Dewitte (2007) and Murphy et al. (2011)) and economics (Fehr et al. (2013)) reported, supports the idea that these two prosocial motives tend to co-occur. Our method allows us to separately investigate the implications of the two types of prosocial behavior for group consumption decisions.

Measuring externalities. We assume the cooperative model as our structural model of group consumption (with and without selfish preferences). This consumption model was originally proposed by Apps and Rees (1988) and Chiappori (1988, 1992), and is nowadays widely used for analyzing multi-person consumption behavior. The model is particularly well-suited for addressing our research question, because it defines rational group consumption as a Pareto efficient allocation over group members. Importantly, this is the sole assumption that is made regarding the intra-group decision process. This reinforces the relevance of the empirical findings, as it avoids bias through additional, more debatable assumptions or a specific game-theoretical set-up. In our particular context, a convenient implication of the

Pareto efficiency assumption is that it allows us to define personalized prices to quantify consumption externalities in monetary terms. Specifically, these personalized prices reveal the willingness-to-pay of each group member for the own consumption, the other's consumption and/or the equality of consumption.

Technically, to identify these personalized prices we will make use of a revealed preference methodology.[2] This methodology has a number of attractive features within the present context. Most notably, it is intrinsically nonparametric, which means that it does not require a prior parametric/functional specification of the individual preferences. This minimizes the risk that our empirical measurement of preference externalities (and the conclusions that are drawn from it) is confounded by some non-verifiable (and, thus, possibly erroneous) structure that is imposed on the consumption decision process. Next, from a practical point of view, the methodology evaluates rationality of group behavior through testable conditions that are easily verified on data sets with a limited number of consumption choices (like in our application). Attractively, this also means that the methodology does not need pooling of consumption data associated with different groups of consumers. The rationality of each group can be evaluated separately, which implies that we can maximally account for inter-group heterogeneity. Thus, our use of revealed preference methods avoids functional misspecification and debatable homogeneity assumptions, which effectively obtains a very "pure" empirical assessment.

Given our particular research interest, we define new "altruism" and "inequality aversion" parameters. Our altruism parameter captures the level of willingness-to-pay for the other's consumption that is required to rationalize the observed consumption as Pareto efficient. Conveniently, the parameter is situated between zero and one and has a natural degree interpretation. The minimal value of zero means that we can rationalize behavior in terms of purely selfish consumers (i.e. consumers only care for the own consumption), while the maximal value of one indicates that rationalization is possible only for consumers who are allowed to care exclusively for the others' consumption (and not for their own consumption). Next, our inequality aversion parameter captures the level of willingness-to-pay for equality of consumption that is required for rationalizability. Once more, the minimal value of zero indicates rationalizability in terms of purely selfish consumers, while the maximal value of one indicates that the group's consumption allocation can only be rationalized through willingness-to-pay for equality.

Thus, lower parameter values generally suggest that behavior is more consistent with the standard model of selfish behavior, while higher values reflect a stronger prevalence of externalities in consumption. By varying the altruism parameter, we can define a whole continuum of models nested between the standard model of purely selfish behavior and the general cooperative model (which allows for unrestricted levels of altruism) in the sense of Browning and Chiappori (1998). By varying the inequality aversion parameter, we extend

[2]See Cherchye et al. (2007, 2011) for revealed preference methodology to assess consumption decisions in terms of the cooperative consumption model. These authors build on early contributions of Samuelson (1938), Afriat (1967), Diewert (1973) and Varian (1982), who focused on rational (i.e. utility maximizing) individual behavior. Sippel (1997) argues that revealed preference methods are particularly useful in combination with experimental data such as the ones used in our own application. See also Harbaugh et al. (2001) and Bruyneel et al. (2012), who use revealed preference methods to assess the rationality of children's individual consumption decisions.

the standard model of purely selfish behavior in an alternative direction, which also adds the possibility of negative consumption externalities to the structural model of cooperative group consumption (see Section 2 for details).

Children and externalities. We use our methodology to investigate the presence of externalities in children's joint consumption behavior. Because observational data on joint consumption decisions made by children are typically not available, we designed a laboratory experiment that is specially tailored to obtain the data required for our revealed preference methodology. In particular, we first randomly assigned the children that participated to our experiment into dyads. Subsequently, we invited these dyads to jointly choose a series of consumption bundles composed of three commodities (grapes, mandarins and letter biscuits). Once these bundles had been selected, we also registered the associated intra-dyad allocations of the quantities, which gave us all the necessary information to identify our altruism and inequality aversion parameters for the consumption choices that were made. We believe that the minimalistic set-up of our experiment contributes to its external validity.[3] The fact that children are allowed to distribute the chosen quantities freely within the dyad implies that there is no clear trade-off between efficiency and equality in our study. This is a natural starting point, since a priori there is no reason for inequality averse children to consume inefficiently.

We have several motivations to select children as a population to illustrate our method. The first motivation is pragmatic. Children have an increasing economic impact, but a disproportionately large chunk of children's economic influence comes through joint decisions, either with their parents (see, for example, Calvert (2008)) or their peers (see, for example, Wouters et al. (2010)). The growing understanding of children's economic rationality (Harbaugh et al. (2002) and Seguin et al. (2007)) is therefore incomplete if we do not know how their decision making is modulated in joint decision making.

By focusing on joint consumption decisions, we extend the analyses of Andreoni and Miller (2002), Fisman et al. (2007) and Cox et al. (2008), who used a revealed preference methodology to investigate individual choices in a modified dictator game. These authors invited individual respondents to divide money between themselves and hypothetical counterparties. However, in many settings, children (i.e. siblings, friends, classmates) jointly decide on which activities to engage in, on how to allocate toys or candy, etc. Therefore, in our study we let the children face a real decision-maker, with whom they interact face-to-face to eventually reach consensus on the within-group consumption allocation. As such, a main feature of our analysis is that we do not treat children as dictatorial decision makers, which – in our opinion – substantially enhances the practical relevance of our findings.

Our second motivation is theoretical. Strategic concerns may distort the impact of prosocial motives (inequality aversion and altruism) on decisions. Recent research indeed showed that thinking about economic decisions in interdependent situations tends to reduce prosocial behavior (Cornelissen et al. (2011) and Cone and Rand (2014)). A child population is therefore particularly suited to study the interplay of these two motives, because their

[3]In this respect, we remark that the type of data that we use in our application are also available in observational (household consumption) settings. This shows the usefulness of our methodology beyond the experimental context that we consider here. We will return to this last point in more detail in the concluding section.

level of strategic thinking is limited (Kromm et al. (2015)) and, hence, their behavior can be considered as more pure. A child population also allows us to investigate the effect of age on the emergence and interplay of the two motives (Eisenberg et al. (2007) and Fehr et al. (2013)). We therefore decided to sample from three ages: kindergarten, third graders, and six graders.

As a final motivation, gaining a deeper insight into the prosocial characteristics of children can provide useful information for parents, caretakers and teachers. In a sense, it assesses the need to "paternalistically" guide children's intra-group consumption allocations. As we discuss in detail further on, there is no clear consensus in the literature on how age, friendship and gender relate to prosocial behavior. The cognitive developments of children are often related to significant changes in prosocial behavior (see, for example, Fehr and Schmidt (1999) for an overview of the literature). As such, we can expect substantial heterogeneity in altruism and/or inequality aversion across children of different ages. Similarly, our set-up allows us to assess the impact of friendship and gender by considering joint consumption decisions of children with various degrees of friendship and/or gender composition.

As a related note, altruism is often modeled by using "caring" preferences in the Beckerian sense. Essentially, this means that others' aggregate utility levels, and not others' consumption quantities per individual good, enter as the direct arguments in individual utility functions.[4] As argued by Chiappori (1992), under Pareto efficiency we have that purely selfish preferences are empirically indistinguishable from caring preferences: the two models have exactly the same testable implications for observed group consumption behavior. In turn, this implies that we cannot meaningfully check the empirical validity of the caring model (relative to the selfish model). Importantly, however, the caring model imposes a rather specific structure on the nature of altruism: it assumes that the marginal rate of substitution between individually consumed goods is independent of the goods consumed by the other. It may often be difficult to convincingly motivate this assumption. For example, it is very likely that children directly compare the quantities consumed per commodity rather than individuals' aggregate utility levels. In the current study, we avoid this interpretational problem by focusing on a more general type of preferences characterized by consumption externalities.

Our experimental analysis leads us to conclude that the purely selfish model (and, hence, also the empirically equivalent caring model) does not provide a good description of the children's observed consumption choices. Positive levels of altruism and inequality aversion considerably improve the goodness-of-fit of our models. It turns out that, for our sample of children, altruism has more impact than inequality aversion. Moreover, we observe substantial heterogeneity in the altruism parameter across children dyads. Therefore, in a following step, we relate the degree of altruism to observable child characteristics, and find that our altruism parameter is significantly correlated with age and friendship. As expected, dyads composed of two good friends also show a higher willingness-to-pay for each other's consumption. Finally, we conclude that children of the sixth grade are generally less altruistic than the younger children (of kindergarten and the third grade).

[4]See Becker (1974, 1991).

Outline. The remainder of this paper unfolds as follows. Section 2 sets out our revealed preference methodology to measure the degree of altruism and inequality aversion. Section 3 presents our experimental design and the results of our empirical application. Section 4 concludes.

2 Group consumption with non-selfish individuals

To set the stage, we first present the cooperative model under the assumption of selfish group members. Then, we introduce two more general models, which depart from the assumption of selfishness in two different directions. The first model encompasses different specifications of altruism, thereby nesting the purely selfish model and the general cooperative model in the spirit of Browning and Chiappori (1998). The second model adds preferences for equality, and extends the cooperative model with negative consumption externalities that stem from inequality aversion. We show that the willingness-to-pay for the others' consumption and the willingness-to-pay for equal consumption is captured by personalized prices. This will enable us to subsequently define intuitive *altruism* and *inequality aversion* parameters. We conclude this section by discussing the independence of our altruism and inequality aversion models. In the Appendix (A, B and D), we consider a general "mixed" model, which simultaneously takes into account altruism and inequality aversion.

Before we can present our models, we first need to specify the type of data that we have in mind when applying our methodology. Our application in Section 3 contains information on dyads' consumption behavior.[5] We have a separate consumption data set for every single dyad, which contains the observed consumption choices for a series of decision situations. Formally, this set takes the form $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ and consists of price vectors $\mathbf{p}_t \in \mathbb{R}^n_{++}$ and quantity vectors $\mathbf{q}_t^m \in \mathbb{R}^n_+$ for every observed decision situation t. Each vector $\mathbf{q}_t^m$ represents the quantities of all goods allocated to individual m ($m = 1, 2$).

2.1 Selfish individuals

The specific feature of selfish consumer behavior is that individual utilities are independent of others' consumption. Formally, in our dyad setting each member m has a utility function $U^m(\mathbf{q}^m)$ that only varies with the own consumption $\mathbf{q}^m$. Throughout we will assume that utility functions are well-behaved.[6] Then, we get the following definition of rational cooperative (i.e. Pareto efficient) consumption behavior under selfishness.

Definition 1 *Consider a data set $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$. A pair of utility functions U^1 and U^2 provides a cooperative rationalization under selfishness of S if and only if, for each observation $t = 1, ..., T$, there exist Pareto weights $\mu_t^1, \mu_t^2 \in \mathbb{R}_{++}$ such that $\mu_t^1 U^1(\mathbf{q}_t^1) + \mu_t^2 U^2(\mathbf{q}_t^2)$ equals*

$$\max_{\mathbf{z}^1,\, \mathbf{z}^2 \in \mathbb{R}^n_+} \mu_t^1 U^1\left(\mathbf{z}^1\right) + \mu_t^2 U^2\left(\mathbf{z}^2\right)$$

[5] We note that it is fairly easy to extend our following methodology towards settings with more than two group members.

[6] That is, we focus on nonsatiated, continuous, nondecreasing in their arguments and concave utility functions.

$$s.t.$$
$$\mathbf{p}_t' \left(\mathbf{z}^1 + \mathbf{z}^2\right) \leq \mathbf{p}_t'(\mathbf{q}_t^1 + \mathbf{q}_t^2).$$

Thus, Pareto efficiency requires that the dyad's consumption behavior can be represented as if it maximizes a weighted sum of the individual utility functions, subject to the dyad's budget constraint (with the dyad's budget equal to $\mathbf{p}_t'(\mathbf{q}_t^1 + \mathbf{q}_t^2)$). We remark that the individual Pareto weights $\mu_t^1, \mu_t^2 \in \mathbb{R}_{++}$ are allowed to vary across the observations t. The implication is that the "bargaining power" of a particular individual need not be constant but may depend on the specific decision situation at hand (defined by prices $\mathbf{p}_t$ and budget $\mathbf{p}_t'(\mathbf{q}_t^1 + \mathbf{q}_t^2)$).

Our revealed preference characterization of rational cooperative behavior uses the concept GARP (Generalized Axiom of Revealed Preference), which is defined as follows.

Definition 2 (GARP) *The set $S^m = \{(\mathbf{p}_t; \mathbf{q}_t^m); t = 1, ..., T\}$ is consistent with GARP if there exists a binary revealed preference relation R such that*

1. *if $\mathbf{p}_t'\mathbf{q}_t^m \geq \mathbf{p}_t'\mathbf{q}_v^m$, then $\mathbf{q}_t^m R \mathbf{q}_v^m$;*
2. *if $\mathbf{q}_t^m R \mathbf{q}_r^m, \mathbf{q}_r^m R \mathbf{q}_s^m, ...\mathbf{q}_u^m R \mathbf{q}_v^m$, then $\mathbf{q}_t^m R \mathbf{q}_v^m$;*
3. *if $\mathbf{q}_t^m R \mathbf{q}_v^m$, then $\mathbf{p}_v'\mathbf{q}_t^m \geq \mathbf{p}_v'\mathbf{q}_v^m$.*

As shown by Varian (1982), consistency with GARP guarantees the existence of an individual utility function U^m that is consistent with the individual m's choices captured by the subset $S^m = \{(\mathbf{p}_t; \mathbf{q}_t^m); t = 1, ..., T\}$. That is, every observed choice $\mathbf{q}_t^m$ maximizes this utility function U^m subject to the budget constraint defined by the prices $\mathbf{p}_t$ and the budget $\mathbf{p}_t\mathbf{q}_t^m$.

We can then present the revealed preference characterization of rational cooperative behavior with selfish dyad members (see Cherchye et al. (2011) for a formal proof).

Proposition 1 *Let $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ be a set of observations. The following statements are equivalent:*

1. *There exists a pair of utility functions U^1 and U^2 that provide a cooperative rationalization under selfishness of S.*
2. *The subsets $S^1 = \{(\mathbf{p}_t; \mathbf{q}_t^1); t = 1, ..., T\}$ and $S^2 = \{(\mathbf{p}_t; \mathbf{q}_t^2); t = 1, ..., T\}$ are both consistent with GARP.*

Varian (1982) presented a combinatorial test of GARP. More recently, Cherchye et al. (2011) have shown that the GARP conditions in Proposition 1 can also be verified by solving a linear programming problem with binary integer variables. A similar programming problem can also be used to verify the revealed preference conditions in our following Propositions 2, 3 and 4, as we discuss in Appendix A.

2.2 Altruistic individuals

Non-selfish consumers typically have other-regarding preferences. Their utility functions are no longer exclusively defined over their own private consumption. In what follows, we investigate two well-known sources of other-regarding preferences: altruism and inequality aversion. We first consider altruism, which implies that consumers care directly for the consumption of others. We present a measure for the degree of altruism in the general collective model. In the next section, we will turn to inequality aversion. In contrast to altruistic individuals, inequality averse consumers care for others' consumption in an indirect way, as they particularly aim at minimizing the intra-dyad difference in consumption.

Formally, altruistic consumers have well-behaved utility functions $U^1(\mathbf{q}^1, \mathbf{q}^2)$ and $U^2(\mathbf{q}^1, \mathbf{q}^2)$. Given our particular research question, we use a definition of rational cooperative behavior that allows for different degrees of altruism. Specifically, we capture the degree of altruism by means of parameters π and ε. We will explain the meaning of these parameters in more detail below.

Definition 3 Consider a data set $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ with $\pi \in [0,1]$. A pair of utility functions U^1 and U^2 provides a cooperative rationalization under $\pi-$altruism of S if and only if, for each observation $t = 1, ..., T$, there exist Pareto weights $\mu_t^1, \mu_t^2 \in \mathbb{R}_{++}$ such that $\mu_t^1 U^1(\mathbf{q}_t^1, \mathbf{q}_t^2) + \mu_t^2 U^2(\mathbf{q}_t^1, \mathbf{q}_t^2)$ equals[7]

$$\max_{\mathbf{z}^1,\, \mathbf{z}^2 \in \mathbb{R}_+^n} \mu_t^1 U^1\left(\mathbf{z}^1, \mathbf{z}^2\right) + \mu_t^2 U^2\left(\mathbf{z}^1, \mathbf{z}^2\right)$$

$$s.t.$$

$$\mathbf{p}_t'\left(\mathbf{z}^1 + \mathbf{z}^2\right) \leq \mathbf{p}_t'(\mathbf{q}_t^1 + \mathbf{q}_t^2),$$

$$\frac{\mu_t^2 \frac{\partial U^2}{\partial z_j^1}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} \leq \varepsilon \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial z_j^2}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \varepsilon \quad \text{with } j = 1, \ldots, n, \tag{1}$$

$$\pi = \frac{\varepsilon}{1+\varepsilon}.$$

In this definition, the parameter ε relates the marginal willingness-to-pay of member m for the consumption of the other member l ($l \neq m$) to l's marginal willingness-to-pay for his/her own consumption of the same commodity.[8] It defines an upper bound on the marginal rate of substitution for every good j between the utility of the other person and own utility. Intuitively, if altruism is very important, the marginal willingness-to-pay for the other's consumption will be large, which implies that the data can be rationalized only for a high value of ε. Generally, by varying the value of ε we obtain rationalization conditions

[7] z_j^m denotes the j-th component of the vector $\mathbf{z}^m$.

[8] Definition 3 uses uniform altruism parameters ε and π. In this respect, we remark that the commodities used in our experiment are all food items of similar nature, which –in our opinion– justifies this choice. Moreover, the parameters essentially bound marginal willingness-to-pay, rather than imposing equality across commodities. Finally, our theory and methodology can easily be generalized to deal with commodity-specific parameters ε_j and π_j. A similar remark applies to the (uniform) inequality aversion parameters γ and δ in Definition 4.

for different degrees of altruism. We illustrate this by considering the two polar cases. First, when $\varepsilon \to \infty$ the conditions (1) impose no additional restrictions on the optimization problem. In other words, altruism may be very large. Next, for $\varepsilon = 0$ we get exactly the same rationalization condition as in Definition 1, which implies purely selfish dyad members.

Fixing the value of ε restricts consumption externalities by constraining the product of the individuals' Pareto weights and marginal utilities. Actually, the fact that we need to constrain both bargaining weights and marginal utilities has an intuitive interpretation. For example, an altruistic dyad member m cannot contribute to the consumption of the other member l if m has no bargaining power. More generally, the marginal willingness-to-pay for others' consumption will depend both on the individuals' marginal utilities for others' consumption and the individuals' Pareto weights.

Conveniently, by using the parameter π we can also derive revealed preference conditions for cooperative rational behavior that are linear in unknowns, which makes them easy to verify in practice. To define these conditions, we need some additional notation. Specifically, we define the personalized prices

$$\mathbf{p}_t^{1,1} = \frac{\mu_t^1}{\lambda_t}\frac{\partial U^1}{\partial \mathbf{z}_t^1}, \mathbf{p}_t^{2,2} = \frac{\mu_t^2}{\lambda_t}\frac{\partial U^2}{\partial \mathbf{z}_t^2} \text{ and}$$

$$\mathbf{p}_t^{1,2} = \frac{\mu_t^1}{\lambda_t}\frac{\partial U^1}{\partial \mathbf{z}_t^2}, \mathbf{p}_t^{2,1} = \frac{\mu_t^2}{\lambda_t}\frac{\partial U^2}{\partial \mathbf{z}_t^1},$$

where λ_t is the Lagrange multiplier associated with the dyad's optimization problem in decision situation t (i.e. the marginal value of income). Intuitively, these personalized prices denote the marginal willingness-to-pay for the own and the other's consumption, respectively.

Using these concepts, we can state the next result, which generalizes Proposition 1.[9]

Proposition 2 Let $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ be a set of observations. The following statements are equivalent:

1. There exists a pair of utility functions U^1 and U^2 that provide a cooperative rationalization under $\pi-$altruism of S.

2. For all $t = 1, ..., T$, there exist non-negative price vectors $\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,2}, \mathbf{p}_t^{2,1}$ and $\mathbf{p}_t^{2,2}$ such that

   (a) the subsets $S^1 = \{(\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,2}; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ and $S^2 = \{(\mathbf{p}_t^{2,1}, \mathbf{p}_t^{2,2}; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ both satisfy GARP;

   (b) $\mathbf{p}_t^{1,1} + \mathbf{p}_t^{2,1} = \mathbf{p}_t = \mathbf{p}_t^{1,2} + \mathbf{p}_t^{2,2}$;

   (c) $\mathbf{p}_t^{2,1} \leq \pi \mathbf{p}_t$ and $\mathbf{p}_t^{1,2} \leq \pi \mathbf{p}_t$.

Condition (a) imposes consistency with GARP on the individual subsets S^1 and S^2. Different from Proposition 1, these conditions are now expressed in terms of the personalized prices $\mathbf{p}_t^{m,m}$ and $\mathbf{p}_t^{m,l}$ (with $m, l = 1, 2$ and $m \neq l$). Next, condition (b) states that these

[9]The proof of our Propositions is presented in Appendix B.

personalized prices must add up (over the dyad members) to the observed prices $\mathbf{p}_t$. This condition follows from our assumption that dyads act cooperatively, which means that they achieve Pareto efficient allocations. Actually, the adding up condition also implies that personalized prices can be interpreted as Lindahl prices associated with the Pareto efficient provision of public goods. This corresponds to the fact that private goods with externalities effectively get a public good character.

Finally, condition (c) includes our altruism parameter π. It follows that π measures the fraction of the value of each member m's consumption bundle financed by his/her partner. More precisely, it puts an upper bound on the monetary contribution of each member for his/her partner's consumption. As such, this measure has an appealing monetary interpretation. If $\pi = 0$, each member fully pays for her own private consumption, i.e. there are no externalities and behavior can be rationalized as purely selfish. We then get exactly the conditions for a rationalization under selfishness that we stated in Proposition 1. Higher values of π enable stronger altruism. In the extreme case with $\pi = 1$, we allow for the possibility that m's consumption is fully financed by the other member l, which means that member m does not contribute to his/her own consumption at all. On a more general level, the altruism parameter π indicates that each dyad member l "pays" (at most) a fraction π of member m's consumption of any good j.

2.3 Inequality averse individuals

Inequality averse consumers care about equality of consumption. Formally, we now use well-behaved utility functions $U^1(\mathbf{q}^1, \mathbf{d})$ and $U^2(\mathbf{q}^2, \mathbf{d})$, in which the vector $\mathbf{d}$ is composed of d_j, $j = 1, \ldots, n$, such that

$$d_j = -|q_j^1 - q_j^2| \text{ with } j = 1, \ldots, n.$$

In words, each entry d_j equals the negative of the absolute intra-dyad difference between the own and the other's consumption. By construction, we have that $d_j \leq 0$. For every good j, the value of d_j quantifies the degree of equality of consumption, with lower values revealing more inequality.

Using this, we can define rational cooperative behavior with alternative degrees of inequality aversion. Similar to before, we capture the degree of inequality aversion by means of two parameters, δ and γ.

Definition 4 Consider a data set $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ and let $d_{t,j} = -|q_{t,j}^1 - q_{t,j}^2|$. Assume $\delta \in [0, 1]$. A pair of utility functions U^1 and U^2 provides a cooperative rationalization under $\delta-$inequality aversion of S if and only if, for each observation $t = 1, ..., T$, there exist Pareto weights $\mu_t^1, \mu_t^2 \in \mathbb{R}_{++}$ such that $\mu_t^1 U^1(\mathbf{q}_t^1, \mathbf{d}_t) + \mu_t^2 U^2(\mathbf{q}_t^2, \mathbf{d}_t)$ equals

$$\max_{\mathbf{z}^1,\, \mathbf{z}^2 \in \mathbb{R}_+^n} \mu_t^1 U^1\left(\mathbf{z}^1, \mathbf{d}\right) + \mu_t^2 U^2\left(\mathbf{z}^2, \mathbf{d}\right)$$

$$s.t.$$

$$\mathbf{p}_t'\left(\mathbf{z}^1 + \mathbf{z}^2\right) \leq \mathbf{p}_t'(\mathbf{q}_t^1 + \mathbf{q}_t^2);$$

$$d_j = -|z_j^1 - z_j^2| \quad \text{with } j = 1, \ldots, n;$$

$$\frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} \leq \gamma \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \gamma \quad \text{with } j = 1, \ldots, n; \tag{2}$$

$$\delta = \frac{\gamma}{1+\gamma}.$$

In this definition, the parameter γ relates the marginal willingness-to-pay for equality of consumption to member m's marginal willingness-to-pay for own consumption. If inequality aversion is important, the marginal willingness-to-pay for equality will be large, which implies that the data can be rationalized only for a high value of γ. Generally, by varying the value of γ we obtain rationalization conditions for different degrees of inequality aversion. In one polar case, we have $\gamma \to \infty$, which means that the conditions (2) impose no additional restrictions on the optimization problem. In other words, inequality aversion may be very large. In the other polar case, we have $\gamma = 0$, and we get exactly the same rationalization condition as in Definition 1, which corresponds to purely selfish dyad behavior.

Importantly, the parameter δ in Definition 4 extends the selfish model in a distinctively different direction than the parameter π in Definition 3. As an implication, a rationalization under 1−inequality aversion is not necessarily nested within a rationalization under 1−altruism (see Section 2.4). Intuitively, whereas the altruism model (with utility functions $U^1(\mathbf{q}^1, \mathbf{q}^2)$ and $U^2(\mathbf{q}^1, \mathbf{q}^2)$) assumes that preferences are non-decreasing in the own and the other's consumption, we have that the inequality aversion model (with $U^1(\mathbf{q}^1, \mathbf{d})$ and $U^2(\mathbf{q}^2, \mathbf{d})$) does allow for *negative* consumption externalities. For example, the derivative of $U^2(\mathbf{q}^2, \mathbf{d})$ with respect to q_j^1 will be negative for $q_j^1 > q_j^2$ (defining $d_j = q_j^2 - q_j^1 < 0$) when the associated derivative with respect to d_j is positive (indicating inequality aversion).

Similar to before, our use of δ in Definition 4 to restrict inequality aversion also allows us to characterize the marginal willingness-to-pay for equality in monetary terms. To see this, we first need to define the personalized prices

$$\mathbf{p}_t^{1,d} = \frac{\mu_t^1}{\lambda_t} \frac{\partial U^1}{\partial \mathbf{d}_t} \text{ and } \mathbf{p}_t^{2,d} = \frac{\mu_t^2}{\lambda_t} \frac{\partial U^2}{\partial \mathbf{d}_t},$$

which have an analogous interpretation as the prices $\mathbf{p}_t^{1,2}$ and $\mathbf{p}_t^{2,2}$ that we used for the altruism model. The basic difference is that the prices $\mathbf{p}_t^{1,d}$ and $\mathbf{p}_t^{2,d}$ reveal willingness-to-pay for equality of consumption, as they capture marginal utilities of consumption equality (measured by $\mathbf{d}_t$).

We can now characterize rationalizable behavior under inequality aversion.

Proposition 3 Let $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ be a set of observations and let $d_{t,j} = -|q_{t,j}^1 - q_{t,j}^2|$. The following statements are equivalent:

1. *There exists a pair of utility functions U^1 and U^2 that provide a cooperative rationalization under δ−inequality aversion of S.*

2. *For all $t = 1, ..., T$, there exist non-negative price vectors $\mathbf{p}_t^{1,1}, \mathbf{p}_t^{2,2}, \mathbf{p}_t^{1,d}$ and $\mathbf{p}_t^{2,d}$ such that*

(a) the subsets $S^1 = \{(\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,d}; \mathbf{q}_t^1, \mathbf{d}_t); t = 1, ..., T\}$ and
$S^2 = \{(\mathbf{p}_t^{2,2}, \mathbf{p}_t^{2,d}; \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ both satisfy GARP;

(b) for all $j = 1, ..., n$

i. if $q_{t,j}^m > q_{t,j}^l$:

$$p_{t,j}^{l,l} + (p_{t,j}^{1,d} + p_{t,j}^{2,d}) = p_{t,j};$$
$$p_{t,j}^{m,m} - (p_{t,j}^{1,d} + p_{t,j}^{2,d}) = p_{t,j};$$
$$p_{t,j}^{1,d} + p_{t,j}^{2,d} \leq \delta p_{t,j};$$

ii. if $q_{t,j}^m = q_{t,j}^l$:

$$p_{t,j}^{1,1} = p_{t,j} = p_{t,j}^{2,2}.$$

As before, condition (a) imposes consistency with GARP on the individual subsets S^1 and S^2.[10] The difference with Proposition 2 is that these conditions are now expressed in terms of personalized prices $\mathbf{p}_t^{1,d}$ and $\mathbf{p}_t^{2,d}$ that specifically relate to inequality aversion.

Next, condition (b) relates the personalized prices to the observed prices $\mathbf{p}_t$. We distinguish two scenarios. In scenario *i*, we have $q_{t,j}^m > q_{t,j}^l$. Then, member m not only pays the price $p_{t,j}$ for an additional unit of $q_{t,j}^m$ but, because of inequality aversion, must also compensate both dyad members for the increased consumption inequality, which implies $p_{t,j}^{m,m} = p_{t,j} + p_{t,j}^{1,d} + p_{t,j}^{2,d}$. Conversely, the other member l receives a monetary subsidy $p_{t,j}^{1,d} + p_{t,j}^{2,d}$ for each unit of $q_{t,j}^l$, because increasing $q_{t,j}^l$ also increases equality.

For this scenario *i*, the inequality aversion parameter δ restricts the fraction of the total marginal willingness-to-pay that stems from inequality aversion. When $\delta = 0$, we get exactly the conditions for a rationalization under selfishness that we stated in Proposition 1. Larger values of δ enable stronger preferences for equality. In the extreme case with $\delta = 1$, we allow for the possibility that l's consumption is fully financed by both members' willingness-to-pay for equal consumption. On a more general level, the inequality aversion parameter δ indicates that (at most) a fraction δ of each member's consumption is financed for reasons of equalizing consumption (rather than intrinsic utility from consumption).

Finally, the consumption of good j is split equally between the dyad members in scenario *ii*. Then, there is no explicit restriction on the shadow prices $p_{t,j}^{1,d}$ and $p_{t,j}^{2,d}$ associated with inequality aversion. Intuitively, it is always optimal to set $p_{t,j}^{1,d} + p_{t,j}^{2,d} = 0$, as this indicates that it is extremely cheap to achieve consumption equality, which effectively rationalizes the observed dyad allocation for good j. As an implication, the individuals' willingness'-to-pay for own consumption must exactly equal the observed price.

2.4 Independence

To conclude, we highlight that the altruism and inequality aversion models are independent. A particular data set may satisfy the conditions for rationalization under altruism in Proposition 2 (for a given value of π) but not the conditions for rationalization under inequality

[10] The definition of GARP for this setting is readily analogous to Definition 2. For compactness we do not include a formal statement.

aversion in Proposition 3 (for a given value of δ), and vice versa. In other words, altruism and inequality aversion models need not to be empirically equivalent.

We illustrate this point by means of two examples. Example 1 provides a data set (with $T = 3$ and $n = 3$) that is consistent with a cooperative rationalization under $1-$inequality but not under $1-$altruism. Next, Example 2 contains a data set (with $T = 2$ and $n = 3$) that satisfies the rationalization conditions for $1-$altruism but not for $1-$inequality.

Example 1 *The following price and quantity data are rationalizable under inequality aversion for $\delta = 1$ but not under altruism for $\pi = 1$ (observations t in rows and goods j in columns)*[11]*:*

$$\mathbf{p} = \begin{bmatrix} 6 & 4 & 1 \\ 9 & 3 & 1 \\ 3 & 1 & 9 \end{bmatrix},$$

$$\mathbf{q}^1 = \begin{bmatrix} \frac{1}{6} & 2 & 0 \\ \frac{2}{3} & 0 & 0 \\ 0 & 0 & \frac{5}{3} \end{bmatrix}, \mathbf{q}^2 = \begin{bmatrix} \frac{1}{2} & 3 & 0 \\ 2 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

As a first step, the next three inequalities hold for this data set:

$$\begin{aligned} \mathbf{p}_1'\mathbf{q}_1 &= 24 > \mathbf{p}_1'(\mathbf{q}_2 + \mathbf{q}_3) = 18.67, \\ \mathbf{p}_2'\mathbf{q}_2 &= 24 > \mathbf{p}_2'(\mathbf{q}_1 + \mathbf{q}_3) = 23.67, \\ \mathbf{p}_3'\mathbf{q}_3 &= 24 > \mathbf{p}_3'(\mathbf{q}_1 + \mathbf{q}_2) = 15. \end{aligned}$$

Then, it follows from Proposition 2 in Cherchye et al. (2007) that these data are inconsistent with cooperative rationalization for any value of π (i.e. the inconsistency result is independent of the restriction that is imposed on the degree of altruism).[12]

However, the same data set is consistent with the inequality aversion model for $\delta = 1$. For example, this conclusion holds for the personalized prices (with $\alpha > 0$ sufficiently small)

$$\mathbf{p}^{1,1} = \begin{bmatrix} 0 & 1+\alpha & 1 \\ (6+\frac{5}{6})-\alpha & 3 & 1 \\ 3 & 1 & 11.7+\alpha \end{bmatrix}, \mathbf{p}^{2,2} = \begin{bmatrix} 12 & 7-\alpha & 1 \\ (11+\frac{1}{6})+\alpha & 3 & 1 \\ 3 & 1 & 6.3-\alpha \end{bmatrix},$$

$$\mathbf{p}^{1,d} = \begin{bmatrix} 6 & 0 & 0 \\ (2+\frac{1}{6})+\alpha & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \mathbf{p}^{2,d} = \begin{bmatrix} 0 & 3-\alpha & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 2.7+\alpha \end{bmatrix}.$$

Specifically, the shadow prices associated with own consumption exceed the corresponding market prices for individual 1 in observation 3 (good 3) and for individual 2 in observations 1 (goods 1 and 2) and 2 (good 1). One can then verify that these prices satisfy the rationalizability conditions in Proposition 3.

[11] The use of zeroes in Example 1 and 2 is only for the ease of exposition.

[12] In particular, the above three inequalities have a similar structure as the ones in Example 1 in Cherchye et al. (2007). These authors have shown that these three inequalities prevent a cooperative rationalization of any data set if negative consumption externalities are excluded.

Example 2 *The following price and quantity data are rationalizable under altruism for* $\pi = 1$ *but not under inequality aversion for* $\delta = 1$*:*

$$\mathbf{p} = \begin{bmatrix} 1 & 8 & 4 \\ 2 & 8 & 3 \end{bmatrix},$$

$$\mathbf{q}^1 = \begin{bmatrix} 0 & 0 & 1 \\ 3 & 0 & 0 \end{bmatrix}, \mathbf{q}^2 = \begin{bmatrix} 0 & 0 & 5 \\ 3 & 0 & 4 \end{bmatrix}.$$

We begin by showing that this data set is inconsistent with the inequality aversion model for $\delta = 1$*. As a first step, for* $t = 1, 2$ *we have that* $d_t^j = 0$ *for* $j = 1, 2$ *and* $d_t^3 = -4$*. As an implication, the terms* d_t^j *are irrelevant for the GARP conditions in Proposition 3, because there is no variation in inequality across the observations* t*. Next, we can use that* $p_{1,1}^{2,2} = 1$*,* $p_{1,2}^{2,2} = 8$ *and* $p_{1,3}^{2,2} > 4$ *imply* $\mathbf{p}_1^{2,2}\mathbf{q}_1^2 > \mathbf{p}_1^{2,2}\mathbf{q}_2^2$*. (The two equalities stem from condition (b) in Proposition 3, and the inequality from the fact that individual 2 consumes more of good 3 than individual 1.) As a result, rationality of individual 2 requires that* $p_{2,3}^{2,2} > 3p_{2,1}^{2,2} = 6$ *(which guarantees* $\mathbf{p}_2^{2,2}\mathbf{q}_2^2 < \mathbf{p}_2^{2,2}\mathbf{q}_1^2$*). In turn,* $p_{2,3}^{2,2} > 6$ *implies* $p_{2,3}^{1,1} < 0$*. However, this last inequality contradicts the assumption that utility is nondecreasing in own consumption. Thus, we conclude that the data set cannot be rationalized in terms of the inequality aversion model.*

Finally, the data set is compatible with the most general altruism model (i.e. $\pi = 1$*). For example, we can use the personalized prices (with* $\alpha > 0$ *sufficiently small)*

$$\mathbf{p}^{1,1} = \begin{bmatrix} 1 & 0 & 2-\alpha \\ 2 & 0 & 3-\alpha \end{bmatrix}, \mathbf{p}^{2,2} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix},$$

$$\mathbf{p}^{1,2} = \begin{bmatrix} 1 & 8 & 4 \\ 2 & 8 & 3 \end{bmatrix}, \mathbf{p}^{2,1} = \begin{bmatrix} 0 & 8 & 2+\alpha \\ 0 & 8 & \alpha \end{bmatrix}.$$

It is easy to verify that these prices satisfy the rationalizability conditions in Proposition 2. Intuitively, individual 1 fully finances the consumption by individual 2, and individual 2 finances more than half of the consumption of good 3 by individual 1.

3 Joint decisions of children

Before we present our empirical results, we first explain our experimental design. In doing so, we will also motivate the empirical questions that we consider further on, with some additional references to the relevant literature. Subsequently, we discuss the main results of our empirical analysis. We find strong evidence that children's joint consumption behavior is systematically characterized by consumption externalities (i.e. non-selfish behavior). Accounting for altruism (more than inequality aversion) particularly helps to rationalize the observed behavior of the children dyads in our sample. Interestingly, we also observe substantial variation in the degree of altruism over the different children in our sample. We relate this variation to observable child characteristics, and find that altruism bears particular relations to age, gender and the degree of friendship.

3.1 Experimental design

Respondents. We collected our data at four different schools. Our sample contains a total of 100 children, who belong to 3 different age categories: 42 from kindergarten, 24 from third grade and 34 from sixth grade. Table 1 presents some basic information for our sample in terms of gender composition and the degree of friendship (explained below). In what follows, we discuss the construction of our sample in more detail, and use this to position our following empirical analysis in the existing literature.

First of all, our sample allows us to link prosocial behavior to children's age. There is some evidence that people in early childhood (aged below 5 years) are less altruistic (see, for example, Eisenberg et al. (2007) for a literature review on the development of prosocial behavior) and more likely to be driven by self-interest (see, for example, Damon (1980) on positive-justice). However, this does not automatically imply a stable and increasing relationship between age and prosocial behavior. On the one hand, Côté et al. (2002) found support for inter-individual stability in prosocial behavior. Similarly, Gummerum et al. (2008) did not find significant age effects on individual allocations in a dictator game. On the other hand, there is also evidence that young school children sometimes act less selfishly. See, for example, Murnighan and Saxon (1998) and Harbaugh et al. (2002), who found that younger children are more likely to accept smaller offers in ultimatum games, or Damon (1980), who found strong evidence of prosocial behavior by children between 5 and 7 years old.

In this respect, a particularly interesting study is the one of Fehr et al. (2013). These authors argue that, beyond the age of about 8 years, the increasing influence of efficiency considerations and strategic behavior may countervail fairness considerations. In a similar vein, it is claimed that the positive effects of a more prosocial orientation are offset by increasing levels of competitiveness as children grow older. Kagan and Madsen (1972) and Toda et al. (1978), for instance, have shown that the level of competition between children increases as a function of age. Summarizing, we may safely conclude that the literature does not show a clear consensus on the relationship between age and selfish preferences. This directly provides a particular motivation for our own empirical application. We deliver empirical input to the debate by considering prosocial behavior in the specific context of children's group consumption decisions.

For each separate age category, we randomly organized the children into dyads, which we then invited to make 9 consumption choices. This resulted in 50 dyads and obtained information on 450 (= 50 x 9) joint decisions. We registered the gender composition of each dyad. There are 19 female dyads, 12 male dyads and 19 dyads consisting of one boy and one girl. Eisenberg et al. (2007) argued that girls are more prosocial than boys. Moreover, girls tend to be somewhat less competitive. Similar to before, our analysis will allow us to investigate this further in a specific consumption context.

Finally, we also registered the intensity of the dyad members' relationship outside the experiment. In particular, we asked the children to label their relationship with respect to the other dyad member as "(very) strong friendship" or "weak (or no) friendship". According to Eisenberg et al. (2007), the literature suggests that children are more likely to share with friends than with less liked peers (see also Buhrmester et al. (1992) and Pilgrim and Rueda-Riedle (2002)). We will investigate this effect in a group consumption context.

		gender	
		boy	girl
grade	kindergarten	4 / 12 / 2	11 / 13 / 0
	thirdgrade	4 / 3 / 2	8 / 7 / 0
	sixthgrade	7 / 8 / 1	5 / 12 / 1

Table 1: Summary statistics on sample composition (x/y/z: x children who indicate (very) strong friendship with their dyad partner, y children who indicate weak (or no) friendship with their dyad partner, z children with missing values on the nature of the relationship)

Design. We invited the children dyads to solve nine successive decision problems. In order to simplify these decision problems, we follow Harbaugh, Krause, and Berry (2001) by defining discrete choice sets, which in our case consist of seven consumption bundles. These bundles are combinations of three nondurable and quickly consumable commodities: grapes (units of 10 grams), mandarins (units of 12.5 grams) and letter biscuits (units of 5 grams). Each choice set corresponds to a unique combination of (implicit) prices and budget: the seven bundles are discrete points on the corresponding budget hyperplane. The implicit budget was 24 in each choice problem, and we guaranteed sufficient price variation to obtain tests of our models with high discriminatory power.[13]

Our experiment was carried out in the classrooms of the four participating schools. We allowed the children to taste our three commodities prior to the experiment. It was emphasized that these "trial commodities" had the same taste and quality as the ones used in the choice problems. To motivate the children to truthfully reveal their preferences in their choice behavior, we told them that they would receive one of their chosen consumption bundles (randomly selected) after the experiment had ended.

For each choice problem, the actual experiment proceeded in two basic steps. In a first step, each dyad of children was asked to select one out of seven possible commodity bundles for the given (implicit) price and budget regimes. The children could take as much time as they wanted to make their joint decisions. In a second step, and in view of our following assessment of externalities, we asked each dyad to define individual shares of the joint consumption bundle that had been chosen, which means that we perfectly observe the shares of the (implicit) dyad budget allocated to each individual member.

Table 2 reports summary statistics on the absolute intra-dyad differences between individual budget shares, which provides some basic insight into the intra-dyad sharing of resources. The table also gives the proportion of dyads that apply (close to) equal resource sharing (i.e. intra-dyad difference between individual resource shares amounts to less than 5 per cent of the available budget). We find that, on average, the resources are shared fairly equally, which actually also provides a specific motivation for our extension of the collective model with inequality aversion. The mean absolute intra-dyad difference in shares amounts to 6.4 per cent. Interestingly, the difference is smallest for dyads containing third graders, while it is largest for dyads with kindergarten respondents. Similarly, we observe that sharing is more equal when children have a strong friendship relationship with their partner. Finally, the gender composition does not seem to have a strong impact on the resource sharing pattern.

[13]We refer to Appendix C for more details on the prices and discrete choice sets that we used.

	Obs	Mean	Std. Dev.	Min	Max	% Equal
all	50	0.064	0.064	0.001	0.29	56.00
kindergarten	21	0.099	0.081	0.004	0.29	33.33
third grade	12	0.029	0.018	0.001	0.06	91.67
sixth grade	17	0.046	0.032	0.004	0.122	58.82
weak friendship	30	0.077	0.076	0.001	0.29	46.67
strong friendship	17	0.048	0.034	0.001	0.122	64.71
two girls	19	0.067	0.065	0.001	0.29	52.63
mixed	19	0.063	0.055	0.001	0.18	52.63
two boys	12	0.062	0.078	0.004	0.29	66.67

Table 2: Intra-dyad budget sharing

Importantly, the goal of our empirical analysis extends beyond simply describing the sharing of resources. This observed sharing is the result of a within-dyad interaction process that is defined by individuals' preferences and bargaining positions. In the subsequent analysis, we investigate if externalities in consumption (altruism or inequality aversion) impact the decision processes that underlie the patterns summarized in Table 2.

3.2 Consumption with or without externalities

Pass rates. For a particular behavioral model (defined by a specific inequality aversion parameter δ or altruism parameter π), we compute the fraction of observed (dyad-specific) data sets that satisfy the corresponding rationalization conditions. We call this fraction our pass rate, which is situated between zero and one by construction. It measures the empirical fit of a given behavioral model. The interpretation is immediate: the better the model describes the observed behavior in our sample, the higher its pass rate will be. In this respect, it directly follows from our above discussion that the pass rate will increase monotonically when the parameters δ and π increase.

We begin our analysis by evaluating the empirical performance of the cooperative consumption model that we characterized in Proposition 3, for alternative values of the inequality aversion parameter δ. We recall that this parameter ranges from zero to one, with $\delta = 0$ indicating purely selfish behavior and $\delta = 1$ defining a least restrictive model that also accounts for the (opposite) scenario in which dyads positively value the consumption of one member *only* because it increases equality (and not for its direct impact of consumption on this member's utility). The associated pass rates are summarized in the first two columns in Table 3. We find that the model with $\delta = 0$, which corresponds to the purely selfish model, explains only 46 per cent of the observed dyads' behavior. By contrast, up to 62 per cent of the dyads' behavior is rationalized for $\delta = 1$. Thus, by allowing for unrestricted levels of inequality aversion, it is possible to rationalize 16 per cent more dyads.

We next consider the pass rates associated with the cooperative consumption model that we characterized in Proposition 2, for alternative values of the altruism parameter π. This parameter can again take any value between zero and one, with $\pi = 0$ indicating purely selfish behavior, and $\pi = 1$ corresponding to a least restrictive model that also includes the (opposite) scenario in which dyad members only care for the other's consumption. We find that the choices of all dyads can be rationalized for $\pi = 1$. The altruism parameter allows us to describe all consumption choices in the sample. Related to this, there seems to be considerable heterogeneity in the degree of altruism across our sample of dyads, as pass rates are gradually increasing from $\pi = 0$ to $\pi = 1$.

Summarizing, these findings give substantial empirical support for consumption models that allow for deviations from purely selfish behavior. In this respect, our data seem to provide a stronger case for models with altruism than for models with inequality aversion. As explained in Section 2.4, the two types of models are independent, so that we may take this as an indication that mainly altruism drives the observed deviations from the purely selfish consumption model.[14] Moreover, the degree of "revealed altruism" varies considerably across dyads. In a following step (described in Section 3.3), we will investigate whether this observed variation bears specific relations to observable child characteristics.

δ	pass rate	π	pass rate
0	0.46	0	0.46
0.1	0.50	0.1	0.52
0.2	0.56	0.2	0.58
0.3	0.56	0.3	0.64
0.4	0.58	0.4	0.70
0.5	0.58	0.5	0.74
0.6	0.60	0.6	0.90
0.75	0.62	0.75	0.94
1	0.62	1	1

Table 3: Pass rates δ and π

Before studying the observed heterogeneity in children's altruism in more detail, we evaluate the robustness of our findings summarized in Table 3. In a first step, we consider the discriminatory power of the rationalizability conditions for the different models that we analyzed (with alternative values for π and δ). After all, a theoretical model has limited use if its behavioral implications have hardly any empirical bite. Next, we will investigate the possible impact of measurement error on our rationalizability conclusions. In particular, we will consider the possibility that prices as perceived by the children when making their choices deviated from the actual (implicit) prices (given in Table 8) that we used to check our conditions.

Discriminatory power. In our above analysis, we have presented a continuum of models, where higher values of δ and π allow for more consumption externalities. Thus, by construction we will have that higher values for δ and π lead to less restrictive consumption models, which makes it easier to pass the corresponding revealed preference conditions. To

[14] As an additional exercise, we have also computed pass rates for general models that simultaneously account for altruism and inequality aversion. The results are given in Appendix D. Generally, these results confirm that, for our sample of dyads, altruism has a more favorable effect on the pass rates than inequality aversion.

account for this trade-off between economic realism (i.e. permit deviations from purely selfish behavior) and restrictiveness, a fair comparison of models with different values for δ and π should simultaneously account for both their empirical fit (i.e. whether or not the data satisfy the associated rationalization conditions) and their discriminatory power (i.e. the extent to which these rationalization conditions can effectively identify irrational behavior). Ideally, a behavioral model combines a good empirical fit with high discriminatory power.

To measure the discriminatory power of a behavioral model, we make use of Bronars (1987)'s power index. This index is based on Becker (1962)'s notion of irrational behavior, i.e. behavior that randomly exhausts the available budget. In our application, we mimic such irrational behavior by randomly sampling from a uniform distribution on the choice sets. In a next step, we randomly allocate the simulated consumption per good among the dyad members. In this way we reconstruct artificial consumption bundles (and the corresponding allocation) for each observed budget set.[15] We repeat this procedure $5,000$ times, which thus defines $5,000$ sets of T "irrational" consumption choices. Bronars' power index equals one minus the fraction of these artificial data sets that pass the rationalization conditions under evaluation. This index will be situated between zero and one. It proxies the probability that the (null) hypothesis of rationality (i.e. consistency with the model) is rejected when the alternative hypothesis (i.e. choices are drawn randomly from a uniform distribution) holds. A high index value signals that the conditions can successfully discriminate between rational and irrational (random) behavior.

In our application, we compute a separate power index for every different dyad. To obtain these dyad-specific indices, we first identify the minimum values of δ (for inequality aversion) and π (for altruism) that allow us to rationalize the observed consumption behavior. Intuitively, these minimum values correspond to minimal deviations from the purely selfish consumption model. Then, we compute the dyad-specific power indices by using the above procedure for these minimal δ- and π-values. As such, our power assessment gives information on the expected distribution of violations under random choice, while incorporating information on the dyads' actual choices. Table 4 summarizes our results for these dyad-specific indices. It reports the average values of the power indices over the subsamples of dyads of which the observed behavior can be rationalized for alternative levels of inequality aversion (δ) and altruism (π).[16]

We find that the standard model with purely selfish consumers is indeed a very stringent one, as it is characterized by an average power index of about 0.97. In other words, (simulated) irrational behavior passes the associated rationalization conditions in less than 3 per cent of the cases. Generally, we observe that the rationalization conditions become more permissive if we leave more room for consumption externalities (i.e. more non-selfish

[15]At this point, it is worth noting that there are several alternatives for defining the power index (see Andreoni et al. (2013) for an overview). The most notable alternative is the bootstrap power, which simulates random bundles by drawing budget shares from the distribution of observed choices (instead of the uniform distribution). As a robustness check, we also used this power measure for our data. For compactness, we do not discuss the results here, but the associated results are qualitatively similar to the ones given in Table 4.

[16]We focus on subsamples with rationalizable behavior for the given δ- and π-values because the corresponding pass rates are equal to one by construction. This gives a natural interpretation to the average power indices in Table 4: deviations from one equal the difference between the pass rate for actual behavior and the pass rate for (simulated) random behavior.

δ	power	π	power
0	0.97	0	0.97
0.1	0.96	0.1	0.94
0.2	0.95	0.2	0.89
0.3	0.94	0.3	0.86
0.4	0.93	0.4	0.83
0.5	0.93	0.5	0.81
0.6	0.92	0.6	0.79
0.75	0.92	0.75	0.77
1	0.91	1	0.75

Table 4: Discriminatory power (π altruism, δ inequality aversion)

behavior, as characterized by higher values of δ and π). However, the average power index is nowhere below 0.75. In other words, even in the most permissive scenario (with $\pi = 1$) the tests can still reject rationalizability for about 75 per cent of the random data sets. The average power index for the least restrictive inequality aversion model (with $\delta = 1$) amounts to 0.91.

Generally, we may conclude that all the models that we investigated do have rationalizability conditions with substantial discriminatory power. Although there is a drop in the power for the altruism model, this does not seem to be enough to explain the much bigger increase in the corresponding pass rates. This suggests that the favorable results in Table 3 for the models with non-selfish individuals (particularly the altruism models) are not simply explained by low power.

Price errors. As explained in Section 3.1, the children in our experiment had to make consumption allocations in two steps: first, they selected one out of seven possible commodity bundles; subsequently, they defined individual shares of the chosen bundle. A particular feature of this allocation process is that it occurred at implicit prices (given in Table 8), which are not observed by the children. This raises the question whether our results are robust to measurement errors, i.e. the actual (implicit) prices may deviate from the prices perceived by the children when making their choices. Therefore, as a second robustness check, we compute pass rates for the altruism and inequality aversion models while accounting for the possibility that prices are measured with error. Specifically, we conduct (weaker) rationalizability checks that account for (a restricted level of) price errors.

To operationalize this idea, we follow the approach of Adams et al. (2014), which itself is based on an original proposal of Varian (1985). In this approach, the "relative price errors" are defined as

$$\eta_{t,j} = \frac{p^*_{t,j} - p_{t,j}}{p_{t,j}},$$

with $p^*_{t,j}$ the perceived prices and $p_{t,j}$ the actual prices.

Because the prices $p^*_{t,j}$ (and the associated measurement errors) are unobserved, we proxy the (unknown) $\eta_{t,j}$-values by the minimal price adjustments that are needed to rationalize the observed choices. We do so by solving the program

$$V = \min \sum_{t=1}^{T} \sum_{j=1}^{n} (\tilde{\eta}_{t,j})^2$$

$$s.t.$$

$$\tilde{p}_{t,j} = (1 + \tilde{\eta}_{t,j}) p_{t,j} \text{ and } S = \{(\tilde{\mathbf{p}}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t \ = 1, ..., T\} \text{ is rationalizable.}$$

Then, we can compute

$$\sigma = \frac{\sqrt{V}}{T \ \times \ n},$$

which gives an estimate of the average price error that we need to make the data satisfy the constraints. Intuitively, if a data set (with actual prices) is fully consistent with the model under consideration, then we can use $\tilde{\eta}_{t,j} = 0$ for all t and j, so that $V = \sigma = 0$.

By using this procedure, we can check rationalizability by accounting for some "maximal permissible" relative price errors/adjustments, which correspond to a maximum possible value for σ. Intuitively, this verifies the rationalizability conditions while allowing for relative price adjustments (in absolute terms) of which the average value (captured by σ) is constrained from above. Clearly, the higher the maximum that is imposed, the more permissive the rationalizability condition becomes. In the limiting case where σ can be arbitrarily large, we get an empty condition as price errors can explain everything.

In our robustness check, we set the maximum equal to 0.01 and, thus, we check whether observed behavior can be rationalized when allowing an average price error of at most 1 per cent. Table 5 shows the associated pass rates. For the fully selfish model we now obtain a pass rate of 60 per cent. Even though this represents a rather substantial improvement over the pass rate of 46 per cent that was reported in Table 3, we still reject behavioral consistency with the selfish model for a large share of the data. Next, the pass rate associated with the inequality aversion model with $\delta = 1$ now amounts to 78 per cent, which represents an improvement of 16 per cent when compared to the model without price errors (see Table 3). This means that we still reject rationalizability for 22 per cent of our sample of dyads even for the most permissive inequality aversion model with price errors. Finally, altruism remains very important to rationalize the observed consumption behavior. At least 40 per cent of the data is characterized by strictly positive willingness-to-pay for other's consumption. In our opinion, this again motivates a more detailed investigation of this altruistic model, which is what we do next.

3.3 Altruism and child characteristics

As argued above, our results provide substantial support for models with altruism. Moreover, there appears to be quite some variation in altruism across the dyads in our sample. We next relate this inter-dyad heterogeneity to observable child characteristics. In particular, we consider children's age, gender and the reported level of intra-dyad friendship.

To address this question, we compute a lower bound on the degree of altruism in each dyad h, which we denote as π^h. For a given data set on dyad consumption choices, we minimize

π	pass rate for $\sigma \leq 0.01$	δ	pass rate for $\sigma \leq 0.01$
0	0.60	0	0.60
0.1	0.66	0.1	0.66
0.2	0.68	0.2	0.68
0.3	0.74	0.3	0.68
0.4	0.80	0.4	0.68
0.5	0.90	0.5	0.70
0.6	0.90	0.6	0.76
0.75	1	0.75	0.78
1	1	1	0.78

Table 5: Pass rates (π altruism, δ inequality aversion) with $\sigma \leq 0.01$

π^h subject to the given rationalization conditions.[17] Basically, this computes the minimal degree of altruism that we need to account for in order to rationalize the observed dyad behavior in terms of the cooperative model.[18] Larger values of π^h indicate that consistency with cooperative group behavior requires greater deviations from purely selfish behavior.

Using this procedure, we can compute an altruism parameter π^h for each different dyad h in our sample. Figure 1 presents the distribution of this altruism parameter for the 50 dyads in our experiment. Consistent with our findings in Table 3, for 46 per cent of the dyads h the value of π^h equals zero. For the remaining children, we need to account for strictly positive levels of altruism to rationalize the observed consumption behavior. Actually, we observe that the cumulative distribution curve is increasing up to π^h as high as 0.8, which reveals a high degree of altruism. Generally, the distribution pattern in Figure 1 effectively reveals considerable heterogeneity in the degree of altruism.

Comparing dyad groups. We first consider how friendship relates to altruism. In particular, we distinguish between two types of dyads: dyads in which children report a (very) strong friendship with their dyad partner, and dyads in which children report a weak (or no) friendship. Our results are displayed in Figure 2. While the two cumulative distribution functions are quite similar for lower degrees of altruism, there is a clear dominance relation for higher levels of altruism. Specifically, for children who are non-selfish, the degree of altruism in behavior is systematically higher when they consider their partners to be strong friends. This indicates that intra-dyad friendship effectively does increase the level of altruism; non-selfish children are willing to contribute more to their friends' material consumption. This is exactly what can be expected from friends, and falls in line with the literature (see, for example, Buhrmester et al. (1992), Pilgrim and Rueda-Riedle (2002) and

[17]To compute these π^h for every dyad h, we abstract from the possibility of price errors. In terms of the procedure outlined at the end of Section 3.2, this corresponds to $\sigma = 0$.

[18]We restrict attention to dyad-specific levels of π. In theory, our tests can perfectly deal with individual-specific levels π^1 and π^2 (i.e. $\mathbf{p}_t^{m,l} \leq \pi^m \mathbf{p}_t$). However, the "optimal" values for π^1 and π^2 will crucially depend on how π^1 and π^2 are aggregated. For example, minimizing $\pi^1 + \pi^2$ implicitly assumes that π^1 and π^2 are perfectly substitutable. Furthermore, our use of a uniform bound π for the two dyad members clearly does allow for unequal personalized prices within dyads.

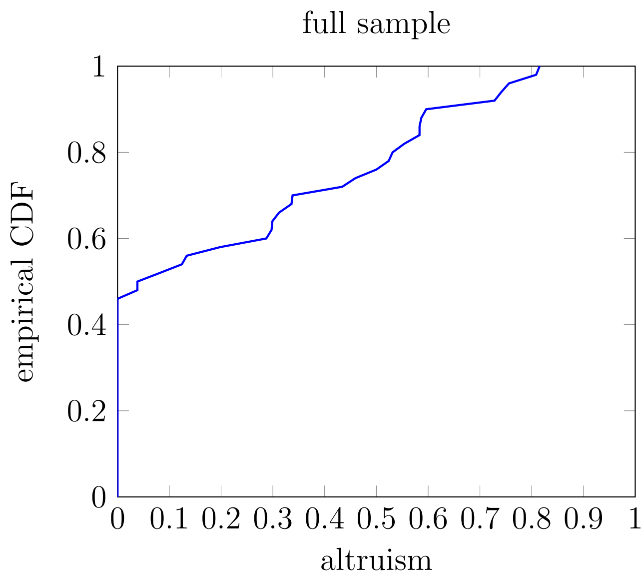

Figure 1: Cumulative distribution of the altruism parameter; whole sample

Eisenberg et al. (2007)). In a sense, this also indicates that our methodology effectively does produce a sensible measure of altruism.

Next, we turn to the gender effect, for which the relevant results are given in Figure 3. We compare the distribution of the degree of altruism for dyads containing only boys and dyads containing at least one girl. In this case, there is no clear first order stochastic dominance relation between the π^h scores for dyads that exclusively contain boys and dyads with girls. However, the results do indicate that the probability of *purely* selfish behavior ($\pi^h = 0$) is considerable larger for all boys dyads. As discussed above, this falls in line with reported evidence that girls generally do tend to act more prosocial (and less competitive).

Finally, we consider the age effect, for which there appeared to be no clear consensus in the literature. The results are summarized in Figure 4. A first observation here is that there is no first order stochastic dominance relation between the π^h scores for kindergarten respondents and third graders. Next, we also find that sixth graders are generally less altruistic than younger children (both kindergarten children and third graders), who seem to be characterized by larger consumption externalities.

At first glance, these results may seem to contradict the conclusion of Eisenberg et al. (2007), which indicates a positive relationship between age and prosocial behavior. In this respect, however, we also recall that around the age of eight years (i.e. third grade) there is a peak in elementary prosocial behavior. Moreover, we also argued that incidences of competitiveness between children and strategic behavior appear to increase with age (see, for example, Kagan and Madsen (1972) and Toda et al. (1978)). As such, our results provide further input to this interesting debate, by focusing on the specific setting of joint consumption decisions. At a more general level, this also motivates the practical usefulness of our methodology.

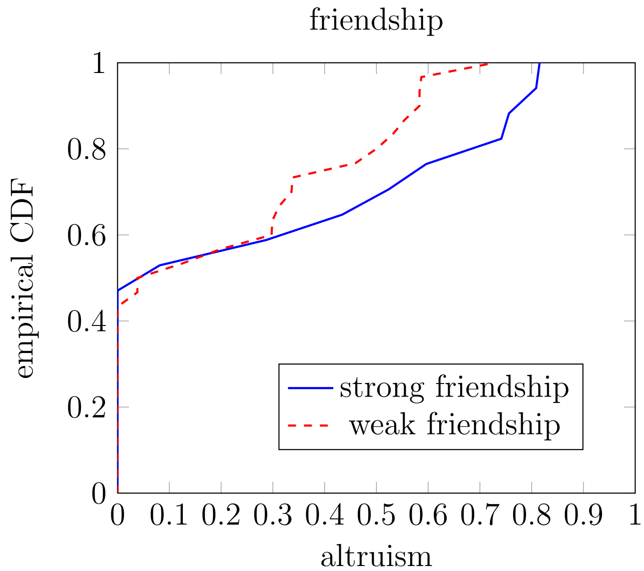

Figure 2: Cumulative distribution of the altruism parameter; strong friendship versus weak friendship

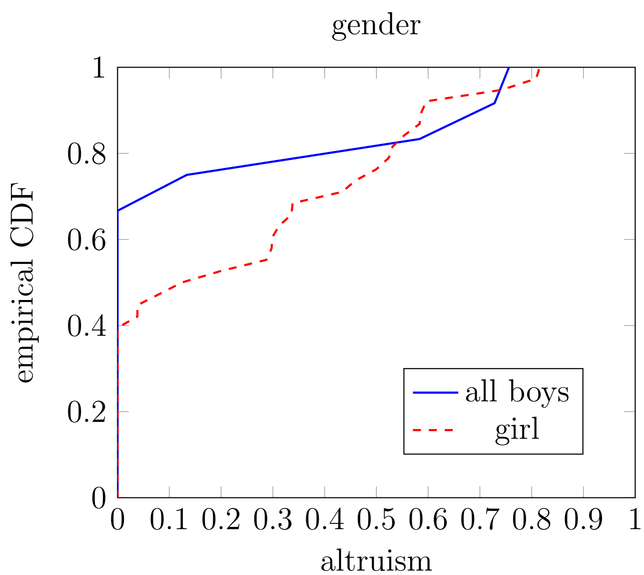

Figure 3: Cumulative distribution of the altruism parameter; boys versus girls

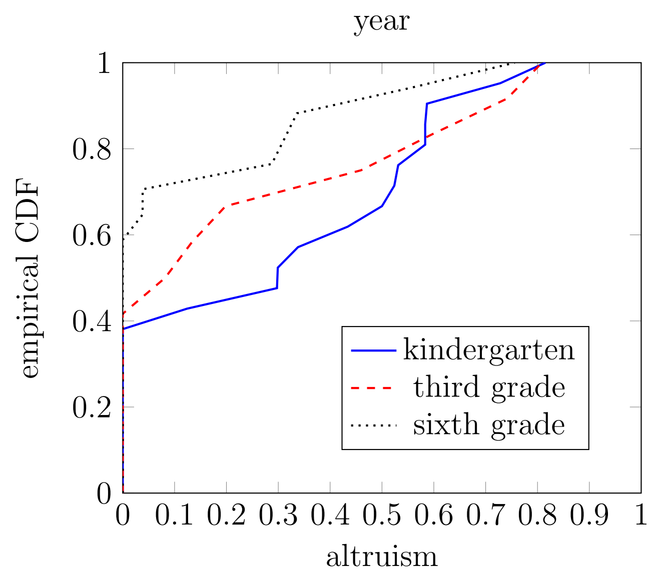

Figure 4: Cumulative distribution of the altruism parameter; kindergarten, third grade and sixth grade

Statistical significance. To verify the statistical meaning of our above conclusions, we carried out Wilcoxon ranksum tests (or Mann-Whitney U tests). The ranksum tests were applied to the entire sample (all dyads) as well as to the (smaller) subsample of dyads for which π^h is strictly positive. The motivation for the latter exercise is that the factors that allow us to discriminate between selfishness and altruism may differ from the factors that govern the precise level of altruism in non-selfish dyads. Related to this, our results in Figure 2 already indicated that the proportion of altruistic (vis-à-vis selfish) dyads is relatively robust to the level of friendship in the dyad, while, at the same time, the level of altruism in non-selfish dyads seems higher among friends.

Basically, each of our exercises compares two populations. The null hypothesis is that two populations have the same distribution for our altruism parameter π. Correspondingly, the alternative hypothesis is that one of the populations systematically has higher values for the parameter than the other. The results of our Wilcoxon tests are given in Table 6.

We find that two effects are statistically significant. First, across all dyads, kindergarten respondents and third graders have a higher rank sum than expected under the null hypothesis, whereas sixth graders have a lower rank sum than expected. Correspondingly, we reject the hypothesis that π is equally distributed for the two groups (i.e. kindergarten respondents and third graders versus sixth graders). Second, for non-selfish dyads, we also observe that dyads in which children are good friends are characterized by higher levels of altruism. These results statistically confirm the patterns in Figures 2 and 4.

Regression analysis. As a final exercise, we investigate whether the above empirical findings of our bivariate analysis remain valid if we condition on different characteristics. Table 7 presents the estimates of two distinct regressions. Similar to before, the first regression aims

Ranksum		all dyads			dyads with $\pi^h > 0$		
		rank sum	expected	P-value	rank sum	expected	P-value
age	0 kind.,thirdg.	920	841.5		304	280	
	1 sixthg.	355	433.5		74	98	
	Combined	1275	1275	0.0906	378	378	0.1842
friendship	0 weak	1015	969		196	229.5	
	1 strong	260	306		155	121.5	
	Combined	1275	1275	0.2715	351	351	0.0710
gender	0 girls	696	720		306	322	
	1 boys	432	408		72	56	
	Combined	1128	1128	0.5777	378	378	0.2748

Table 6: Ranksum tests

at explaining variation in π^h for the whole sample, whereas the second regression explains variation for the subsample of dyads with $\pi^h > 0$. We regress our altruism parameter on the variables age, gender composition and level of (intra-dyad) friendship.[19] To do so, we follow a proposal by Papke and Wooldridge (1996).[20] These authors assumed that the variables of interest are independently distributed, and that the conditional expectation of π^h takes the form

$$E(\pi^h|\mathbf{x}^h) = G(\mathbf{x}^h\beta),$$

with $\mathbf{x}^h$ a vector of observed characteristics per dyad h, and $G(\cdot)$ a known function with $0 < G(z) < 1$ for all z. We use that $G(\cdot)$ is the logistic cumulative distribution function.

This approach imposes no assumptions on the underlying structure that is used to obtain π^h. For estimation, the authors proposed to maximize the Bernouilli log-likelihood function with individual contributions given by

$$L_h(\beta) = \pi^h \log[G(\mathbf{x}^h\beta)] + (1 - \pi^h)\log[1 - G(\mathbf{x}^h\beta)].$$

In our application, π^h can take any value between 0 and 1 (including 0 and 1). While a standard regression (OLS) on transformed data (e.g. the logit transformation) cannot properly deal with values at the boundary, Papke and Wooldridge's estimation technique can take these values into account. The estimates $\hat{\beta}$ are consistent and $\sqrt{N}$-asymptotically normal regardless of the distribution of π^h on $\mathbf{x}^h$.

Our results are presented in Table 7. As our data set is quite small, we may expect few significant effects a priori. This also turns out to be the case for most of the variables in our regression for the full sample. Still, the kindergarten dummy has a positive impact on altruism (compared to the sixth grade reference age), and this last effect is statistically significant in both regressions.

[19] Gender composition is a dummy variable (boys dyad) that indicates whether all group members are boys. Strong friendship is a dummy variable (strong friendship dyad) that indicates whether *both* members reported positive (strong or very strong) levels of friendship.

[20] This method requires specifying robust standard errors, a logit link function and the binomial distribution. It is available in STATA under the command 'glm y x, link(logit) family(binomial) robust'.

	all dyads	dyads with $\pi^h > 0$
constant	-1.927***	-1.132***
	(0.478)	(0.396)
kindergarten	1.088**	0.729*
	(0.554)	(0.396)
third grade	0.584	0.541
	(0.645)	(0.514)
boys dyad	-0.372	1.188***
	(0.690)	(0.276)
strong friendship dyad	0.594	0.765**
	(0.464)	(0.321)
obs	47	26

Table 7: Regression of altruism on age, gender composition and intra-dyad level of friendship (columns 1-2: whole sample, columns 3-4: observations with $\pi > 0$), with robust standard errors between brackets (***: significant at the 1%-level, **: significant at the 5%-level, *: significant at the 10%-level)

Moreover, dyads consisting of boys only are characterized by higher levels of altruism in non-selfish dyads. By eliminating the large share of selfish boy dyads, we end up with a higher level of altruism for boys. Notice that this effect is only observed conditional on age and gender, as it is not confirmed by the corresponding results in Table 6.

Finally, strong friendship has a positive impact on the altruism of (non-selfish) dyads. The result is consistent with our observation from Table 6 and the patterns depicted in Figure 2. This provides additional empirical support for our above conclusions regarding friendship and consumption externalities, which appear to be robust even if we condition on age and gender (despite our small sample size). This is an interesting observation because, as indicated above, these findings have particular intuitive appeal.

4 Conclusion

We discussed how to extend the purely selfish model of group consumption behavior by imposing specific structure on patterns of altruism and inequality aversion. Importantly, this generalizes the selfish model in two distinctively different directions. We have shown that altruism and inequality aversion models are independent in terms of empirical implications: consumption behavior that fits one model needs not necessarily fit the other model. Intuitively, the explanation is that inequality aversion allows for negative consumption externalities, which is excluded in the case of altruism. It makes that we can separately investigate the implications of the two types of prosocial behavior for group consumption decisions.

Next, we have introduced a revealed preference method to quantify the willingness-to-pay for the consumption of others, as well as the willingness-to-pay for consumption equality. Within the framework of the cooperative (i.e. Pareto efficient) consumption model, we measure willingness-to-pay for others' consumption by evaluating consumption externalities in monetary terms. Interestingly, the method allows us to define an altruism parameter and an inequality aversion parameter. Each of these parameters characterizes a continuum of models with varying degrees of consumption externalities.

Finally, we have shown the practical usefulness of our method by an application to consumption choices made by dyads of children. We find that children's consumption decisions are systematically characterized by externalities (i.e. non-selfish preferences). In particular, for our sample of children, we find strong support for altruism models (more than for inequality aversion models). Interestingly, we also observed substantial heterogeneity across children in the degree of altruism, which we related to differences in age, gender and degree of friendship between dyad members. For our sample, we found that sixth graders behave less altruistically than third graders and kindergarten children. Furthermore, children tend to act more altruistically in joint consumption decisions when they have a strong friendship with the other group members.

We see several avenues for further research. At the methodological level, we can extend our revealed preference characterizations to other types of social (or other-regarding) preferences (see, for example, Sobel (2005) for a recent review). For example, we could use our revealed preference approach to devise testable implications of alternative models that define particular origins of positive and/or negative externalities (including envy). This can be used to investigate whether different models are empirically distinguishable from each other in revealed preference terms. And, if so, we can relate the applicability of specific models to the (observable) characteristics of the individuals at hand.

At the empirical level, our application has used data that we collected through a specially designed consumption experiment. This experiment clearly showed the potential of our approach to empirically explore relations between non-selfish behavior and individual characteristics. In this first study we used only a fairly limited amount of information on observed characteristics (i.e. age, gender and friendship). Obviously, richer data sets (also including more observations) can obtain a more detailed analysis of the drivers of externalities. For example, this may imply a deeper investigation of the relationship between age and non-selfishness.

Finally, in this study we used experimental data because our focus was on children's consumption. However, our revealed preference methodology can also be used in combination with observational data. For example, an interesting application may identify the degree of consumption externalities in household consumption, and relate inter-household heterogeneity in our altruism and inequality aversion parameters to specific household (member) characteristics. In this respect, we can also refer to Cherchye et al. (2009, 2011) for empirical studies of household consumption behavior that make use of revealed preference methods similar to ours.

Interestingly, data sets with detailed information on the intra-household consumption allocation are increasingly available. Notable examples are the Dutch Longitudinal Internet Studies for the Social Sciences (LISS) panel and the Japanese Panel Survey of Consumers (JPSC). See, for example, Cherchye et al. (2012) for an application of the cooperative model to the LISS data, and Lise and Yamada (2014) for an application to the JPSC data. These studies focus on households' time use allocations (including the supply of home and market labor) and the associated trade-off between consumption and leisure, hereby exploiting wage variation as a prime source of price variation. Given that our methodology can attach different levels of altruism and/or inequality aversion to different commodities, it is possible to compare the intra-household externalities generated by leisure and private consumption, respectively.

References

Adams, A., Cherchye, L., De Rock, B., Verriest, E., 2014. Consume now or later? time inconsistency, collective choice and revealed preference. American Economic Review 104, 4147–4183.

Afriat, S. N., 1967. The construction of utility functions from expenditure data. International Economic Review 8, 67–77.

Andreoni, J., Gillen, B. J., Harbaugh, W. T., 2013. The power of revealed preference tests: Ex-post evaluation of experimental design. Tech. rep., UCLA Department of Economics.

Andreoni, J., Miller, J., 2002. Giving according to garp: An experimental test of the consistency of preferences for altruism. Econometrica 70, 737–753.

Apps, P., Rees, R., 1988. Taxation and the household. Journal of Public Economics 35, 355–369.

Becker, G. S., 1962. Irrational behavior and economic theory. Journal of Political Economy 70, 1–13.

Becker, G. S., 1974. A theory of social interactions. Journal of Political Economy 82, 1063–1093.

Becker, G. S., 1991. A Treatise on the Family. Harvard University Press.

Bolton, G. E., Ockenfels, A., 2000. Erc: A theory of equity, reciprocity, and competition. American Economic Review 90, 166–193.

Bronars, S. G., 1987. The power of nonparametric tests of preference maximization. Econometrica 55, 693–698.

Browning, M., Chiappori, P.-A., 1998. Efficient intra-household allocations: a general characterization and empirical tests. Econometrica 66, 1241–1278.

Bruyneel, S., Cherchye, L., Cosaert, S., De Rock, B., Dewitte, S., 2012. Are the smart kids more rational? Tech. Rep. CES DP12.16, KULeuven.

Buhrmester, D., Goldfarb, J., Cantrell, D., 1992. Self-presentation when sharing with friends and nonfriends. Journal of Early Adolescence 12, 61–79.

Calvert, S. L., 2008. Children as consumers: Advertising and marketing. Future of Children 18, 205–234.

Charness, G., Rabin, M., 2002. Understanding social preferences with simple tests. Quarterly Journal of Economics 117, 817–869.

Cherchye, L., De Rock, B., Vermeulen, F., 2007. The collective model of household consumption: a nonparametric characterization. Econometrica 75, 553–574.

Cherchye, L., De Rock, B., Vermeulen, F., 2009. Opening the black box of intra-household decision-making. Journal of Political Economy 117, 1142–1163.

Cherchye, L., De Rock, B., Vermeulen, F., 2011. The revealed preference approach to collective consumption behaviour: testing and sharing rule recovery. Review of Economic Studies 78, 176–198.

Cherchye, L., De Rock, B., Vermeulen, F., 2012. Married with children. a collective labor supply model with detailed time use and intrahousehold expenditure information. American Economic Review 102, 3377–3405.

Chiappori, P., 1988. Rational household labor supply. Econometrica 56, 63–89.

Chiappori, P., 1992. Collective labor supply and welfare. Journal of Political Economy 100, 437–467.

Cone, J., Rand, D., 2014. Time pressure increases cooperation in competitively framed social dilemmas. PloS one 9.

Cornelissen, G., Dewitte, S., Warlop, L., 2011. Are social value orientations expressed automatically? Personality and Social Psychology Bulletin 37, 1080–1090.

Côté, S., Tremblay, R. E., Nagin, D., Zoccolillo, M., Vitaro, F., 2002. The development of impulsivity, fearfulness, and helpfulness during childhood: Patterns of consistency and change in the trajectories of boys and girls. Journal of Child Psychology and Psychiatry 43, 609–618.

Cox, J. C., Friedman, D., Sadiraj, V., 2008. Revealed altruism. Econometrica 76, 31–69.

Damon, W., 1980. Patterns of change in children's social reasoning: A two-year longitudinal study. Child Development 51, 1010–1017.

Diewert, W. E., 1973. Afriat and revealed preference theory. Review of Economic Studies 40, 419–425.

Eisenberg, N., Fabes, R. A., Spinrad, T. L., 2007. Handbook of child psychology. Ch. Prosocial development.

Engelmann, D., Strobel, M., 2004. Inequality aversion, efficiency, and maximin preferences in simple distribution experiments. American Economic Review 94, 857–869.

Fehr, E., Glätzle-Rützler, D., Sutter, M., 2013. The development of egalitarianism, altruism, spite and parochialism in childhood and adolescence. European Economic Review 64, 369–383.

Fehr, E., Schmidt, K. M., 1999. A theory of fairness, competition, and cooperation. Quarterly Journal of Economics 114, 817–868.

Fisman, R., Kariv, S., Markovits, D., 2007. Individual preferences for giving. American Economic Review 97, 1858–1876.

Gummerum, M., Keller, M., Takezawa, M., Mata, J., 2008. To give or not to give: children's and adolescents' sharing and moral negotiations in economic decision situations. Child Development 79, 562–576.

Harbaugh, W. T., Krause, K., Berry, T. R., 2001. GARP for kids: On the development of rational choice behavior. American Economic Review 91, 1539–1545.

Harbaugh, W. T., Krause, K., Liday, S. G., 2002. Bargaining by children. Tech. rep., University of Oregon Economics Department working Papers.

Kagan, S., Madsen, M., 1972. Rivalry in anglo-american and mexican children of two ages. Journal of Personality and Social Psychology 24, 214–220.

Kromm, H., Färber, M., Holodynski, M., 2015. Felt or false smiles? volitional regulation of emotional expression in 4, 6, and 8 year old children. Child Development 86, 579–597.

Lise, J., Yamada, K., 2014. Household sharing and commitment: Evidence from panel data on individual expenditures and time use. IFS Working Papers W14/05.

Millet, K., Dewitte, S., 2007. Altruistic behavior as a costly signal of general intelligence. Journal of Research in Personality 41, 316–326.

Murnighan, J. K., Saxon, M. S., 1998. Ultimatum bargaining by children and adults. Journal of Economic Psychology 19, 415–445.

Murphy, R., Ackermann, K., Handgraaf, M., 2011. Measuring social value orientation. Judgment and Decision Making 6 (8), 771–781.

Papke, L., Wooldridge, J., 1996. Econometric methods for fractional response variables with an application to 401 (k) plan participation rates. Journal of Applied Econometrics 11, 619–632.

Pilgrim, C., Rueda-Riedle, A., 2002. The importance of social context in cross-cultural comparisons: First graders in columbia and the united states. Journal of Genetic Psychology 163, 283–295.

Rabin, M., 2013. An approach to incorporating psychology into economics. American Economic Review 103, 617–622.

Samuelson, P. A., 1938. A note on the pure theory of consumer's behavior. Economica 5, 61–71.

Seguin, J., Arseneault, L., Tremblay, R., 2007. The contribution of "cool" and "hot" components of decision-making in adolescence: Implications for developmental psychopathology. Cognitive Development 22, 530–543.

Sippel, R., 1997. An experiment on the pure theory of consumer's behaviour. Economic Journal 107, 1431–1444.

Sobel, J., 2005. Interdependent preferences and reciprocity. Journal of Economic Literature 43, 392–436.

Toda, M., Shinotsuka, H., McClintock, C. G., Stech, F. J., 1978. Development of competitive behavior as a function of culture, age, and social comparison. Journal of Personality and Social Psychology 36, 825–839.

van Lange, P. A., 1999. The pursuit of joint outcomes and equality in outcomes: An integrative model of social value orientation. Journal of Personality and Social Psychology 77 (2), 337.

Varian, H., 1982. The nonparametric approach to demand analysis. Econometrica 50, 945–974.

Varian, H. R., 1985. Non-parametric analysis of optimizing behavior with measurement error. Journal of Econometrics 30, 445–458.

Wouters, E., Larsen, J., Kremers, S., Dagnelie, P., Geenen, R., 2010. Peer influence on snacking behavior in adolescence. Appetite 55, 11–17.

A Other-regarding preferences: a general model

To focus our discussion, we have treated altruism models and inequality aversion models distinctly in the main text. Because the two types of models are independent (see Section 2.4), it can be useful to consider "mixed" models that simultaneously allow for strictly positive levels of altruism and inequality aversion. As argued in the text, the literature on prosocial behavior often considers both sources of other-regarding preferences simultaneously.

Formally, mixed models define general well-behaved utility functions that depend on own consumption, the other's consumption and equality of consumption. The adaptation of the objective functions in Definitions 3 and 4 is straightforward. Specifically, we now get

$$\mu_t^1 U^1\left(\mathbf{z}^1, \mathbf{z}^2, \mathbf{d}\right) + \mu_t^2 U^2\left(\mathbf{z}^1, \mathbf{z}^2, \mathbf{d}\right).$$

In what follows, we will define necessary and sufficient conditions for a data set to be rationalizable in terms of this general model. We will also show how these conditions can be operationalized by solving a linear programming problem with binary variables. As the altruism and inequality aversion models can be formulated as special cases of this general model, our following discussion directly carries over to these more specific models.

As before, let π (and ε) capture the magnitude of altruism and let δ (and γ) measure the degree of inequality aversion.

Definition 5 Consider a data set $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ and let $d_{t,j} = -|q_{t,j}^1 - q_{t,j}^2|$. Assume $\pi, \delta \in [0, 1]$. A pair of utility functions U^1 and U^2 provides a cooperative rationalization under $\pi-$altruism and $\delta-$inequality aversion of S if and only if, for each observation $t = 1, ..., T$, there exist Pareto weights $\mu_t^1, \mu_t^2 \in \mathbb{R}_{++}$ such that $\mu_t^1 U^1 (\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t) + \mu_t^2 U^2 (\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t)$ equals

$$\max_{\mathbf{z}^1,\ \mathbf{z}^2 \in \mathbb{R}_+^n} \mu_t^1 U^1 \left(\mathbf{z}^1, \mathbf{z}^2, \mathbf{d}\right) + \mu_t^2 U^2 \left(\mathbf{z}^1, \mathbf{z}^2, \mathbf{d}\right)$$

$$s.t.$$

$$\mathbf{p}_t' \left(\mathbf{z}^1 + \mathbf{z}^2\right) \leq \mathbf{p}_t'(\mathbf{q}_t^1 + \mathbf{q}_t^2);$$

$$d_j = -|z_j^1 - z_j^2| \quad \text{with } j = 1, \ldots, n;$$

$$\frac{\mu_t^2 \frac{\partial U^2}{\partial z_j^1}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} \leq \varepsilon \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial z_j^2}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \varepsilon \quad \text{with } j = 1, \ldots, n;$$

$$\frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} \leq \gamma \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \gamma \quad \text{with } j = 1, \ldots, n;$$

$$\pi = \frac{\varepsilon}{1+\varepsilon}; \delta = \frac{\gamma}{1+\gamma}.$$

This model includes the models in Definitions 1, 3 and 4 as special cases. More specifically, the model in Definition 5 coincides with the egoistic model when $\pi = \delta = 0$, i.e. when other-regarding preferences are excluded. Second, it is equivalent to the altruism model (Definition 3) when there is no inequality aversion ($\delta = 0$). Finally, it is equivalent to the inequality aversion model (Definition 4) when altruism is excluded ($\pi = 0$).

We can use this generalization to simultaneously test for combinations of altruism and inequality aversion (π, δ). In particular, we can derive the following proposition, which generalizes Propositions 1, 2 and 3 in the main text (Appendix B contains the proof).

Proposition 4 Let $S = \{(\mathbf{p}_t; \mathbf{q}_t^1, \mathbf{q}_t^2); t = 1, ..., T\}$ be a set of observations and let $d_{t,j} = -|q_{t,j}^1 - q_{t,j}^2|$. The following statements are equivalent:

1. There exists a pair of utility functions U^1 and U^2 that provide a cooperative rationalization under $\pi-$altruism and $\delta-$inequality aversion of S.

2. For all $t = 1, ..., T$, there exist non-negative price vectors $\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,2}, \mathbf{p}_t^{2,1}, \mathbf{p}_t^{2,2}, \mathbf{p}_t^{1,d}$ and $\mathbf{p}_t^{2,d}$ such that

   (a) the subsets $S^1 = \{(\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,2}, \mathbf{p}_t^{1,d}; \mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ and $S^2 = \{(\mathbf{p}_t^{2,1}, \mathbf{p}_t^{2,2}, \mathbf{p}_t^{2,d}; \mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ both satisfy GARP;

   (b) for all $j = 1, ..., n$

i. if $q^m_{t,j} > q^l_{t,j}$:

$$p^{l,l}_{t,j} + p^{m,l}_{t,j} + (p^{1,d}_{t,j} + p^{2,d}_{t,j}) = p_{t,j};$$
$$p^{m,m}_{t,j} + p^{l,m}_{t,j} - (p^{1,d}_{t,j} + p^{2,d}_{t,j}) = p_{t,j};$$
$$(p^{1,d}_{t,j} + p^{2,d}_{t,j}) \leq \delta(p^{l,l}_{t,j} + p^{1,d}_{t,j} + p^{2,d}_{t,j});$$

ii. if $q^m_{t,j} = q^l_{t,j}$:

$$p^{1,1}_{t,j} + p^{2,1}_{t,j} = p_{t,j} = p^{1,2}_{t,j} + p^{2,2}_{t,j};$$

(c) $\mathbf{p}^{2,1}_t \leq \pi(\mathbf{p}^{1,1}_t + \mathbf{p}^{2,1}_t); \mathbf{p}^{1,2}_t \leq \pi(\mathbf{p}^{2,2}_t + \mathbf{p}^{1,2}_t)$.

As before, condition (a) imposes consistency with GARP on the individual subsets S^1 and S^2. Next, condition (b) states that the individuals' marginal willingness'-to-pay must sum up to the commodity's price $p_{t,j}$. Intuitively, δ captures the monetary contribution from inequality aversion, relative to the willingness-to-pay for own consumption.[21] Similarly, in condition (c), π restricts the monetary contribution from altruism, relative to the willingness-to-pay for own consumption.

To operationalize these conditions, we use binary variables $x^m_{t,s} \in \{0, 1\}$ to represent the preference relations R^m. Specifically $x^m_{t,s} = 1$ if $(\mathbf{q}^1_t, \mathbf{q}^2_t, \mathbf{d}_t)$ R^m $(\mathbf{q}^1_s, \mathbf{q}^2_s, \mathbf{d}_s)$ and $x^m_{t,s} = 0$ otherwise. Then, consistency with the conditions in Proposition 4 requires that there must exist a solution for the following programming problem (with C_t an arbitrary number that exceeds the total budget in observation t):

$$\mathbf{p}^{m,l}_t \leq \pi(\mathbf{p}^{l,l}_t + \mathbf{p}^{m,l}_t), \tag{3}$$
$$\mathbf{p}^{m,m\prime}_t(\mathbf{q}^m_t - \mathbf{q}^m_v) + \mathbf{p}^{m,l\prime}_t(\mathbf{q}^l_t - \mathbf{q}^l_v) + \mathbf{p}^{m,d\prime}_t(\mathbf{d}_t - \mathbf{d}_v) < x^M_{t,v}C_t, \tag{4}$$
$$x^M_{t,s} + x^M_{s,v} \leq 1 + x^M_{t,v}, \tag{5}$$
$$\mathbf{p}^{m,m\prime}_v(\mathbf{q}^m_v - \mathbf{q}^m_t) + \mathbf{p}^{m,l\prime}_v(\mathbf{q}^l_v - \mathbf{q}^l_t) + \mathbf{p}^{m,d\prime}_v(\mathbf{d}_v - \mathbf{d}_t) \leq (1 - x^M_{t,v})C_v, \tag{6}$$

$$\begin{bmatrix} p^{l,l}_{t,j} + p^{m,l}_{t,j} + (p^{1,d}_{t,j} + p^{2,d}_{t,j}) = p_{t,j} \\ p^{m,m}_{t,j} + p^{l,m}_{t,j} - (p^{1,d}_{t,j} + p^{2,d}_{t,j}) = p_{t,j} \\ (p^{1,d}_{t,j} + p^{2,d}_{t,j}) \leq \delta(p^{l,l}_{t,j} + p^{1,d}_{t,j} + p^{2,d}_{t,j}) \end{bmatrix} \; if \;\; q^m_{t,j} > q^l_{t,j}, \tag{7}$$

$$\tag{8}$$

$$\left[p^{1,1}_{t,j} + p^{2,1}_{t,j} = p_{t,j} = p^{1,2}_{t,j} + p^{2,2}_{t,j}\right] \;\; if \; q^m_{t,j} = q^l_{t,j}. \tag{9}$$

Given information on private quantities $\mathbf{q}^m$ and market prices $\mathbf{p}$, and conditional on (π, δ), the conditions are linear in the unknowns $\mathbf{p}^{m,m}_t$, $\mathbf{p}^{m,l}_t$ and $\mathbf{p}^{m,d}_t$ and binary variables $x^m_{t,s}$.

[21]Notice that $(p^{1,d}_{t,j} + p^{2,d}_{t,j}) \leq \delta(p^{l,l}_{t,j} + p^{1,d}_{t,j} + p^{2,d}_{t,j})$ also implies $(p^{1,d}_{t,j} + p^{2,d}_{t,j}) \leq \delta(p^{m,m}_{t,j} + p^{1,d}_{t,j} + p^{2,d}_{t,j})$ given that $p^{m,m}_{t,j} \geq p_{t,j} \geq p^{l,l}_{t,j}$ in scenario *i*.

Constraints (3) and (7)-(9) follow immediately from Proposition 4. Further, constraints (4)–(6) comply with the Generalized Axiom of Revealed Preference (GARP) for each individual m (= 1 or 2). Specifically, constraint (4) states that $\mathbf{p}_t^{m,m\prime}(\mathbf{q}_t^m - \mathbf{q}_v^m) + \mathbf{p}_t^{m,l\prime}(\mathbf{q}_t^l - \mathbf{q}_v^l) + \mathbf{p}_t^{m,d\prime}(\mathbf{d}_t - \mathbf{d}_v) \geq 0$ implies $x_{t,v}^m = 1$ (or $(\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t)\ R^m\ (\mathbf{q}_v^1, \mathbf{q}_v^2, \mathbf{d}_v)$). Next, constraint (5) imposes transitivity of the individual revealed preference relations R^m: if $x_{t,s}^m = 1$ (i.e. $(\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t)\ R^m\ (\mathbf{q}_s^1, \mathbf{q}_s^2, \mathbf{d}_s)$) and $x_{s,v}^m = 1$ (i.e. $(\mathbf{q}_s^1, \mathbf{q}_s^2, \mathbf{d}_s)\ R^m\ (\mathbf{q}_v^1, \mathbf{q}_v^2, \mathbf{d}_v)$) then $x_{t,v}^m = 1$ (i.e. $(\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t)\ R^m\ (\mathbf{q}_v^1, \mathbf{q}_v^2, \mathbf{d}_v)$). And constraint (6) requires $\mathbf{p}_v^{m,m\prime}(\mathbf{q}_v^m - \mathbf{q}_t^m) + \mathbf{p}_v^{m,l\prime}(\mathbf{q}_v^l - \mathbf{q}_t^l) + \mathbf{p}_v^{m,d\prime}(\mathbf{d}_v - \mathbf{d}_t) \leq 0$ if $x_{t,v}^m = 1$ (i.e. $(\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t)\ R^m\ (\mathbf{q}_v^1, \mathbf{q}_v^2, \mathbf{d}_v)$).

B Proof of Proposition 4

We prove the equivalence between a cooperative rationalization under $\pi-$altruism and $\delta-$inequality aversion and the corresponding revealed preference characterization in Proposition 4. Obviously, this also proves Propositions 2 and 3.

Necessity. We show that statement *1* implies statement *2*, i.e. the existence of a pair of utility functions U^1 and U^2 that provide a cooperative rationalization under $(\pi, \delta)-$other-regarding preferences implies that there exist non-negative price vectors $\mathbf{p}_t^{1,1}$, $\mathbf{p}_t^{2,2}$, $\mathbf{p}_t^{1,2}$, $\mathbf{p}_t^{2,1}$, $\mathbf{p}_t^{1,d}$ and $\mathbf{p}_t^{2,d}$ such that the subsets $S^1 = \{(\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,2}, \mathbf{p}_t^{1,d}; \mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ and $S^2 = \{(\mathbf{p}_t^{2,1}, \mathbf{p}_t^{2,2}, \mathbf{p}_t^{2,d}; \mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ are both consistent with the GARP and such that the conditions on these price vectors hold.

In a first step, we derive the first-order conditions associated with the optimization problem in Definition 5:

$$\begin{aligned}
\mu_t^1 \frac{\partial U^1}{\partial q_{t,j}^1} + \mu_t^2 \frac{\partial U^2}{\partial q_{t,j}^1} + (\mu_t^1 \frac{\partial U^1}{\partial d_{t,j}} + \mu_t^2 \frac{\partial U^2}{\partial d_{t,j}}) \frac{\partial d_j}{\partial q_{t,j}^1} &\leq \lambda_t p_{t,j}, \\
\mu_t^2 \frac{\partial U^2}{\partial q_{t,j}^2} + \mu_t^1 \frac{\partial U^1}{\partial q_{t,j}^2} + (\mu_t^1 \frac{\partial U^1}{\partial d_{t,j}} + \mu_t^2 \frac{\partial U^2}{\partial d_{t,j}}) \frac{\partial d_j}{\partial q_{t,j}^2} &\leq \lambda_t p_{t,j},
\end{aligned}$$

with $\frac{\partial U^m}{\partial \mathbf{q}_t^m}$, $\frac{\partial U^l}{\partial \mathbf{q}_t^m}$ and $\frac{\partial U^l}{\partial \mathbf{d}_t}$ $(m, l = 1, 2, m \neq l)$ the supergradients of the functions U^1 and U^2 with respect to $\mathbf{q}_t^m$ and $\mathbf{d}_t$, both evaluated at $(\mathbf{q}_t^1, \mathbf{q}_t^2)$. At this point, we can define personalized prices as follows:

$$\begin{aligned}
\mathbf{p}_t^{1,2} &= \frac{\mu_t^1}{\lambda_t} \frac{\partial U^1}{\partial \mathbf{q}_t^2}, \mathbf{p}_t^{2,1} = \frac{\mu_t^2}{\lambda_t} \frac{\partial U^2}{\partial \mathbf{q}_t^1}, \\
\mathbf{p}_t^{1,d} &= \frac{\mu_t^1}{\lambda_t} \frac{\partial U^1}{\partial \mathbf{d}_t}, \mathbf{p}_t^{2,d} = \frac{\mu_t^2}{\lambda_t} \frac{\partial U^2}{\partial \mathbf{d}_t},
\end{aligned}$$

$$
\begin{aligned}
p^{1,1}_{t,j} &= p_{t,j} - \frac{\mu^2_t}{\lambda_t}\frac{\partial U^2}{\partial q^1_{t,j}} - (\mu^1_t \frac{\partial U^1}{\partial d_{t,j}} + \mu^2_t \frac{\partial U^2}{\partial d_{t,j}})\frac{\partial d_j}{\partial q^1_{t,j}},\\
p^{2,2}_{t,j} &= p_{t,j} - \frac{\mu^1_t}{\lambda_t}\frac{\partial U^1}{\partial q^2_{t,j}} - (\mu^1_t \frac{\partial U^1}{\partial d_{t,j}} + \mu^2_t \frac{\partial U^2}{\partial d_{t,j}})\frac{\partial d_j}{\partial q^2_{t,j}}.
\end{aligned}
$$

This obtains that $p^{1,1}_{t,j} + p^{2,1}_{t,j} + (p^{1,d}_{t,j} + p^{2,d}_{t,j})\frac{\partial d_j}{\partial q^1_{t,j}} = p_{t,j} = p^{1,2}_{t,j} + p^{2,2}_{t,j} + (p^{1,d}_{t,j} + p^{2,d}_{t,j})\frac{\partial d_j}{\partial q^2_{t,j}}$, *which gives condition 2b* (note that given our definition of $d(\cdot)$ we have that $\frac{\partial d_j}{\partial q^m_{t,j}} = 1$ if $q^m_{t,j} < q^l_{t,j}$, $\frac{\partial d_j}{\partial q^m_{t,j}} = -1$ if $q^m_{t,j} > q^l_{t,j}$ and $\frac{\partial d_j}{\partial q^l_{t,j}} = 0$ if $q^l_{t,j} = q^m_{t,j}$). Moreover, the above shows that

$$
\mathbf{p}^{1,1}_t \geq \frac{\mu^1_t}{\lambda_t}\frac{\partial U^1}{\partial \mathbf{q}^1_t}, \mathbf{p}^{2,2}_t \geq \frac{\mu^2_t}{\lambda_t}\frac{\partial U^2}{\partial \mathbf{q}^2_t}.
$$

In a second step, we use that the individual utility functions are concave. As such,

$$
\begin{aligned}
U^1(\mathbf{q}^1_s, \mathbf{q}^2_s, \mathbf{d}_s) - U^1(\mathbf{q}^1_t, \mathbf{q}^2_t, \mathbf{d}_t) &\leq \frac{\partial U^{1\prime}}{\partial \mathbf{q}^1_t}(\mathbf{q}^1_s - \mathbf{q}^1_t) + \frac{\partial U^{1\prime}}{\partial \mathbf{q}^2_t}(\mathbf{q}^2_s - \mathbf{q}^2_t)\\
&\quad + \frac{\partial U^{1\prime}}{\partial \mathbf{d}_t}(\mathbf{d}_s - \mathbf{d}_t),\\
U^2(\mathbf{q}^2_s, \mathbf{q}^1_s, \mathbf{d}_s) - U^2(\mathbf{q}^2_t, \mathbf{q}^1_t, \mathbf{d}_t) &\leq \frac{\partial U^{2\prime}}{\partial \mathbf{q}^2_t}(\mathbf{q}^2_s - \mathbf{q}^2_t) + \frac{\partial U^{2\prime}}{\partial \mathbf{q}^1_t}(\mathbf{q}^1_s - \mathbf{q}^1_t)\\
&\quad + \frac{\partial U^{2\prime}}{\partial \mathbf{d}_t}(\mathbf{d}_s - \mathbf{d}_t).
\end{aligned}
$$

By taking $\eta^m_t = \frac{\lambda_t}{\mu^m_t}$, and given the definitions of $\mathbf{p}^{1,1}_t$, $\mathbf{p}^{2,2}_t$, $\mathbf{p}^{1,2}_t$, $\mathbf{p}^{2,1}_t$, $\mathbf{p}^{1,d}_t$ and $\mathbf{p}^{2,d}_t$, we then effectively obtain

$$
\begin{gathered}
U^1(\mathbf{q}^1_s, \mathbf{q}^2_s, \mathbf{d}_s) - U^1(\mathbf{q}^1_t, \mathbf{q}^2_t, \mathbf{d}_t) \leq \eta^1_t \mathbf{p}^{1,1\prime}_t(\mathbf{q}^1_s - \mathbf{q}^1_t)\\
+\eta^1_t \mathbf{p}^{1,2\prime}_t(\mathbf{q}^2_s - \mathbf{q}^2_t) + \eta^1_t \mathbf{p}^{1,d\prime}_t(\mathbf{d}_s - \mathbf{d}_t),\\
U^2(\mathbf{q}^2_s, \mathbf{q}^1_s, \mathbf{d}_s) - U^2(\mathbf{q}^2_t, \mathbf{q}^1_t, \mathbf{d}_t) \leq \eta^2_t \mathbf{p}^{2,2\prime}_t(\mathbf{q}^2_s - \mathbf{q}^2_t)\\
+\eta^2_t \mathbf{p}^{2,1\prime}_t(\mathbf{q}^1_s - \mathbf{q}^1_t) + \eta^2_t \mathbf{p}^{2,d\prime}_t(\mathbf{d}_s - \mathbf{d}_t).
\end{gathered}
$$

Taking $U^m(\mathbf{q}^m_s, \mathbf{q}^l_s, \mathbf{d}_s) = U^m_s$ results exactly into the Afriat inequalities applied to our framework. Varian (1982) proved the equivalence between consistency with the Afriat inequalities and consistency with the GARP. Hence, we have shown that the data set must be such that $S^1 = \{(\mathbf{p}^{1,1}_t, \mathbf{p}^{1,2}_t, \mathbf{p}^{1,d}_t; \mathbf{q}^1_t, \mathbf{q}^2_t, \mathbf{d}_t); t = 1, ..., T\}$ and $S^2 = \{(\mathbf{p}^{2,1}_t, \mathbf{p}^{2,2}_t, \mathbf{p}^{2,d}_t; \mathbf{q}^1_t, \mathbf{q}^2_t, \mathbf{d}_t); t = 1, ..., T\}$ are both consistent with the GARP. *This gives condition 2a.*

In a final step, we must take into account that the utility functions U^1 and U^2 were restricted to satisfy

$$\begin{aligned}
\frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} &\leq \gamma \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \gamma \quad \text{with } j = 1, \ldots, n, \\
\frac{\mu_t^2 \frac{\partial U^2}{\partial z_j^1}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} &\leq \varepsilon \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial z_j^2}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \varepsilon \quad \text{with } j = 1, \ldots, n.
\end{aligned}$$

Using the above notation, we can rewrite this in terms of personalized prices:

$$\begin{aligned}
\frac{p_{t,j}^{1,d} + p_{t,j}^{2,d}}{p_{t,j}^{1,1}} &\leq \gamma \text{ and } \frac{p_{t,j}^{1,d} + p_{t,j}^{2,d}}{p_{t,j}^{2,2}} \leq \gamma \quad \text{with } j = 1, \ldots, n, \\
\frac{p_{t,j}^{2,1}}{p_{t,j}^{1,1}} &\leq \varepsilon \text{ and } \frac{p_{t,j}^{1,2}}{p_{t,j}^{2,2}} \leq \varepsilon \quad \text{with } j = 1, \ldots, n.
\end{aligned}$$

This gives

- $\varepsilon \mathbf{p}_t^{1,1} \geq \mathbf{p}_t^{2,1}$ and $\varepsilon \mathbf{p}_t^{2,2} \geq \mathbf{p}_t^{1,2}$. Hence $\varepsilon(\mathbf{p}_t^{1,1} + \mathbf{p}_t^{2,1}) \geq (1+\varepsilon)\mathbf{p}_t^{2,1}$ and $\varepsilon(\mathbf{p}_t^{2,2} + \mathbf{p}_t^{1,2}) \geq (1+\varepsilon)\mathbf{p}_t^{1,2}$ or $\mathbf{p}_t^{2,1} \leq \pi(\mathbf{p}_t^{1,1} + \mathbf{p}_t^{2,1})$ and $\mathbf{p}_t^{1,2} \leq \pi(\mathbf{p}_t^{2,2} + \mathbf{p}_t^{1,2})$ with $\pi = \dfrac{\varepsilon}{1+\varepsilon}$.
- $\gamma \mathbf{p}_t^{1,1} \geq \mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d}$ and $\gamma \mathbf{p}_t^{2,2} \geq \mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d}$. Hence $\gamma(\mathbf{p}_t^{1,1} + \mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d}) \geq (1+\gamma)(\mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d})$ and $\gamma(\mathbf{p}_t^{2,2} + \mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d}) \geq (1+\gamma)(\mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d})$ or $\mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d} \leq \delta(\mathbf{p}_t^{1,1} + \mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d})$ and $\mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d} \leq \delta(\mathbf{p}_t^{2,2} + \mathbf{p}_t^{1,d} + \mathbf{p}_t^{2,d})$ with $\delta = \dfrac{\gamma}{1+\gamma}$. This concludes the necessity part.

Sufficiency. We start from the condition (2a) that both data sets S^1 and S^2 must be consistent with the GARP. From Varian (1982), we know that consistency of $S^1 = \{(\mathbf{p}_t^{1,1}, \mathbf{p}_t^{1,2}, \mathbf{p}_t^{1,d}; \mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ and $S^2 = \{(\mathbf{p}_t^{2,1}, \mathbf{p}_t^{2,2}, \mathbf{p}_t^{2,d}; \mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t); t = 1, ..., T\}$ with GARP is equivalent to the existence of utility numbers u_t^m and Lagrange multipliers η_t^m such that for $m, l = 1, 2$:

$$\begin{aligned}
u_s^m - u_t^m \leq\ & \eta_t^m \mathbf{p}_t^{m,m\prime}(\mathbf{q}_s^m - \mathbf{q}_t^m) + \eta_t^m \mathbf{p}_t^{m,l\prime}(\mathbf{q}_s^l - \mathbf{q}_t^l) \\
& + \eta_t^m \mathbf{p}_t^{m,d\prime}(\mathbf{d}_s - \mathbf{d}_t).
\end{aligned}$$

By using these Afriat-like inequalities, we can construct utility functions U^1 and U^2 that rationalize the observed data. For any pair of quantity vectors $(\mathbf{z}^1, \mathbf{z}^2)$ (with $d_{t,j} = -|z_j^1 - z_j^2|$) we can define (for $m = 1, 2$)

$$U^m(\mathbf{z}^1, \mathbf{z}^2, \mathbf{d}) = \min_{s \in \{1,\ldots,T\}} [U_s^m + \eta_s^m [(\mathbf{p}_s^{m,1\prime}\mathbf{z}^1 + \mathbf{p}_s^{m,2\prime}\mathbf{z}^2 + \mathbf{p}_s^{m,d\prime}\mathbf{d}) - (\mathbf{p}_s^{m,1\prime}\mathbf{q}_s^1 + \mathbf{p}_s^{m,2\prime}\mathbf{q}_s^2 + \mathbf{p}_s^{m,d\prime}\mathbf{d}_s)]].$$

Let us show that these utility functions effectively provide a cooperative rationalization under π-altruism and δ-inequality aversion. First of all, Varian (1982) has proven that the utility functions are well-behaved and that $U^m(\mathbf{q}_t^1, \mathbf{q}_t^2, \mathbf{d}_t) = U_t^m$. Then, for strictly positive μ_t^m, we can simply add up the utility functions of different group members and obtain the following condition:

$$\begin{aligned}\sum_{m,l=1,2,m\neq l} \mu_t^m U^m(\mathbf{z}^m, \mathbf{z}^l, \mathbf{d}) \;\; \leq & \sum_{m,l=1,2,m\neq l} \mu_t^m [U_t^m + \eta_t^m [(\mathbf{p}_t^{m,m\prime}\mathbf{z}^m + \mathbf{p}_t^{m,l\prime}\mathbf{z}^l + \mathbf{p}_t^{m,d\prime}\mathbf{d}) \\ & -(\mathbf{p}_t^{m,m\prime}\mathbf{q}_t^m + \mathbf{p}_t^{m,l\prime}\mathbf{q}_t^l + \mathbf{p}_t^{m,d\prime}\mathbf{d}_t)]].\end{aligned}$$

For the remainder of the proof, we set $\mu_t^m = 1/\eta_t^m$ and thus we have

$$\begin{aligned}\sum_{m,l=1,2,m\neq l} \mu_t^m U^m(\mathbf{z}^m, \mathbf{z}^l, \mathbf{d}) \;\; \leq & \sum_{m,l=1,2,m\neq l} \mu_t^m U_t^m + [(\mathbf{p}_t^{m,m\prime}\mathbf{z}^m + \mathbf{p}_t^{m,l\prime}\mathbf{z}^l + \mathbf{p}_t^{m,d\prime}\mathbf{d}) \\ & -(\mathbf{p}_t^{m,m\prime}\mathbf{q}_t^m + \mathbf{p}_t^{m,l\prime}\mathbf{q}_t^l + \mathbf{p}_t^{m,d\prime}\mathbf{d}_t)].\end{aligned}$$

Take any $(\mathbf{z}^1, \mathbf{z}^2)$ that satisfy $\mathbf{p}_t'\mathbf{z}^1 + \mathbf{p}_t'\mathbf{z}^2 \leq \mathbf{p}_t'\mathbf{q}_t^1 + \mathbf{p}_t'\mathbf{q}_t^2$. For each good j there are two distinct cases.

CASE 1 $\quad q_{t,j}^1 = q_{t,j}^2$:

$$\begin{aligned} & (p_{t,j}^{1,1} z_j^1 + p_{t,j}^{1,2} z_j^2) - (p_{t,j}^{1,1} q_{t,j}^1 + p_{t,j}^{1,2} q_{t,j}^2) + (p_{t,j}^{2,2} z_j^2 + p_{t,j}^{2,1} z_j^1) - (p_{t,j}^{2,2} q_{t,j}^2 + p_{t,j}^{2,1} q_{t,j}^1) \\ & +(p_{t,j}^{1,d} + p_{t,j}^{2,d})(d_j - d_{t,j}) \\ = \;& p_{t,j} z_j^1 + p_{t,j} z_j^2 - p_{t,j} q_{t,j}^1 - p_{t,j} q_{t,j}^2 + (p_{t,j}^{1,d} + p_{t,j}^{2,d})(d_j - d_{t,j}) \\ \leq \;& p_{t,j} z_j^1 + p_{t,j} z_j^2 - p_{t,j} q_{t,j}^1 - p_{t,j} q_{t,j}^2. \end{aligned} \tag{10}$$

The first equality follows from $p_{t,j}^{1,1} + p_{t,j}^{2,1} = p_{t,j} = p_{t,j}^{2,2} + p_{t,j}^{1,2}$ (2b), the first inequality follows from $(p_{t,j}^{1,d} + p_{t,j}^{2,d})(d_j - d_{t,j}) = 0$ since $d_{t,j} = 0$.

CASE 2 $\quad q_{t,j}^1 \neq q_{t,j}^2$:

$$\begin{aligned} & (p_{t,j}^{1,1} z_j^1 + p_{t,j}^{1,2} z_j^2) - (p_{t,j}^{1,1} q_{t,j}^1 + p_{t,j}^{1,2} q_{t,j}^2) + (p_{t,j}^{2,2} z_j^2 + p_{t,j}^{2,1} z_j^1) - (p_{t,j}^{2,2} q_{t,j}^2 + p_{t,j}^{2,1} q_{t,j}^1) \\ & +(p_{t,j}^{1,d} + p_{t,j}^{2,d})(d_j - d_{t,j}) \\ \leq \;& (p_{t,j}^{1,1} z_j^1 + p_{t,j}^{1,2} z_j^2) - (p_{t,j}^{1,1} q_{t,j}^1 + p_{t,j}^{1,2} q_{t,j}^2) + (p_{t,j}^{2,2} z_j^2 + p_{t,j}^{2,1} z_j^1) - (p_{t,j}^{2,2} q_{t,j}^2 + p_{t,j}^{2,1} q_{t,j}^1) \\ & +(p_{t,j}^{1,d} + p_{t,j}^{2,d})(\frac{\partial d_j}{\partial q_{t,j}^1}(z_j^1 - q_{t,j}^1) + \frac{\partial d_j}{\partial q_{t,j}^2}(z_j^2 - q_{t,j}^2)) \\ = \;& p_{t,j} z_j^1 + p_{t,j} z_j^2 - p_{t,j} q_{t,j}^1 - p_{t,j} q_{t,j}^2. \end{aligned} \tag{11}$$

The first inequality follows from the fact that $d_{t,j} = -|z_j^1 - z_j^2|$ is concave in z_j^1 and z_j^2. The equality follows from $p_{t,j}^{1,1} + p_{t,j}^{2,1} + (p_{t,j}^{1,d} + p_{t,j}^{2,d})\frac{\partial d_j}{\partial q_{t,j}^1} = p_{t,j} = p_{t,j}^{1,2} + p_{t,j}^{2,2} + (p_{t,j}^{1,d} + p_{t,j}^{2,d})\frac{\partial d_j}{\partial q_{t,j}^2}$, that is condition (2b).

Summing over all goods (i.e. summing the expressions 10 and 11), we obtain $\mathbf{p}_t'\mathbf{z}^1 + \mathbf{p}_t'\mathbf{z}^2 - \mathbf{p}_t'\mathbf{q}_t^1 - \mathbf{p}_t'\mathbf{q}_t^2$, which is smaller than zero due to the budget constraint. Hence, we obtain

$$\sum_{m,l=1,2,m\neq l} \mu_t^m U^m(\mathbf{z}^m, \mathbf{z}^l) \leq \sum_{m,l=1,2,m\neq l} \mu_t^m U_t^m = \sum_{m,l=1,2,m\neq l} \mu_t^m U(\mathbf{q}_t^m, \mathbf{q}_t^l, \mathbf{d}_t).$$

This shows that $(\mathbf{q}_t^1, \mathbf{q}_t^2)$ maximizes the group's objective function subject to $\mathbf{p}_t'\mathbf{z}^1 + \mathbf{p}_t'\mathbf{z}^2 \leq \mathbf{p}_t'\mathbf{q}_t^1 + \mathbf{p}_t'\mathbf{q}_t^2$. As such, we have constructed a pair of utility functions that cooperatively rationalizes the data under π-altruism and δ-inequality aversion.

To finish the proof, we need to show that our constructed utility functions satisfy

$$\frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^2}} \leq \gamma \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \gamma \quad \text{with } j = 1, \ldots, n,$$

$$\frac{\mu_t^2 \frac{\partial U^2}{\partial z_j^1}}{\mu_t^1 \frac{\partial U^1}{\partial z_j^1}} \leq \varepsilon \text{ and } \frac{\mu_t^1 \frac{\partial U^1}{\partial z_j^2}}{\mu_t^2 \frac{\partial U^2}{\partial z_j^2}} \leq \varepsilon \quad \text{with } j = 1, \ldots, n.$$

In order to do this, we use that (with $m, l = 1, 2, m \neq l$) $\mathbf{p}_t^{2,1} \leq \pi(\mathbf{p}_t^{1,1} + \mathbf{p}_t^{2,1})$, $\mathbf{p}_t^{1,2} \leq \pi(\mathbf{p}_t^{2,2} + \mathbf{p}_t^{1,2})$ and $\varepsilon = \dfrac{\pi}{1-\pi}$ (for $\pi \neq 1$), which shows that

$$\varepsilon = \frac{\pi}{1-\pi} \geq \frac{p_{t,j}^{l,m}}{p_{t,j}^{m,m}}.$$

Above, we have constructed utility functions $U^m(\mathbf{q}^1, \mathbf{q}^2, \mathbf{d})$ from the Afriat inequalities. The supergradients of these functions must satisfy the following conditions:

$$\begin{aligned} \frac{\partial U^m}{\partial \mathbf{q}_t^m} &\leq \eta_t^m \mathbf{p}_t^{m,m}, \\ \frac{\partial U^l}{\partial \mathbf{q}_t^m} &\leq \eta_t^l \mathbf{p}_t^{l,m}. \end{aligned}$$

Using $\mu_t^m = 1/\eta_t^m$ and $\varepsilon \geq \dfrac{p_{t,j}^{l,m}}{p_{t,j}^{m,m}}$, $m, l = 1, 2$, and $m \neq l$, we effectively obtain that

$$\varepsilon \geq \frac{p_{t,j}^{l,m}}{p_{t,j}^{m,m}} = \frac{\frac{1}{\eta_t^l} \frac{\partial U^l}{\partial q_{t,j}^m}}{\frac{1}{\eta_t^m} \frac{\partial U^m}{\partial q_{t,j}^m}} = \frac{\mu_t^l \frac{\partial U^l}{\partial q_{t,j}^m}}{\mu_t^m \frac{\partial U^m}{\partial q_{t,j}^m}} = \frac{\frac{\mu_t^l}{\lambda_t} \frac{\partial U^l}{\partial q_{t,j}^m}}{\frac{\mu_t^m}{\lambda_t} \frac{\partial U^m}{\partial q_{t,j}^m}}.$$

A similar reasoning shows

$$\gamma \geq \frac{p_{t,j}^{1,d} + p_{t,j}^{2,d}}{p_{t,j}^{m,m}} = \frac{\mu_t^1 \frac{\partial U^1}{\partial d_j} + \mu_t^2 \frac{\partial U^2}{\partial d_j}}{\mu_t^m \frac{\partial U^m}{\partial q_{t,j}^m}}.$$

C Discrete choice sets

Tables 8 and 9 present the (implicit) prices and discrete choice sets for the 9 decision problems of our experiment. To recall, the (implicit) budget equals 24 in each decision problem.

Prices		
1 unit of grapes	1 unit of mandarins	1 unit of letter biscuits
8	4	1
8	3	2
9	3	1
1	8	4
2	8	3
1	9	3
4	1	8
3	2	8
3	1	9

Table 8: Prices

D General model of other-regarding preferences: pass rates

Table 10 reports the pass rates of general models of other-regarding preferences, which account for both altruism (π) and inequality aversion (δ). Obviously, the first row of Table 10 (with values ranging from 0.46 to 0.62) gives the results of the inequality aversion model in Table 3, whereas the first column (with values ranging from 0.46 to 1) gives the results of the altruism model in Table 3.

In general, the results in Table 10 confirm that allowing for altruism has a more favorable effect on the pass rates than allowing for inequality aversion. In fact, the pass rates of models that combine both sources of consumption externalities can also be interesting on their own. For example, under the restriction that both π and δ cannot exceed 0.5, we can rationalize the consumption behavior of 86 per cent of the dyads in our sample. By contrast, limited altruism (with $\pi \leq 0.5$) without inequality aversion (i.e. $\delta = 0$) can rationalize only 74% of the observed dyads' behavior, while limited inequality aversion (with $\delta \leq 0.5$) without altruism (i.e. $\pi = 0$) obtains a pass rate of no more than 58%.

	Quantities	
Grapes	Mandarins	Biscuits
Choice 1		
3	0	0
0	6	0
0	0	24
1	2	8
1.5	0	12
1.5	3	0
0	3	12
Choice 2		
3	0	0
0	8	0
0	0	12
1	2.66	4
1.5	0	6
1.5	4	0
0	4	6
Choice 3		
2.66	0	0
0	8	0
0	0	24
0.88	2.66	8
1.32	0	12
1.32	4	0
0	4	12
Choice 4		
0	3	0
0	0	6
24	0	0
8	1	2
12	1.5	0
0	1.5	3
12	0	3
Choice 5		
0	3	0
0	0	8
12	0	0
4	1	2.66
6	1.5	0
0	1.5	4
6	0	4
Choice 6		
0	2.66	0
0	0	8
24	0	0
8	0.88	2.66
12	1.32	0
0	1.32	4
12	0	4
Choice 7		
0	0	3
6	0	0
0	24	0
2	8	1
0	12	1.5
3	0	1.5
3	12	0
Choice 8		
0	0	3
8	0	0
0	12	0
2.66	4	1
0	6	1.5
4	0	1.5
4	6	0
Choice 9		
0	0	2.66
8	0	0
0	24	0
2.66	8	0.88
0	12	1.32
4	0	1.32
4	12	0

Table 9: The 9 discrete choices sets

	δ	0	0.1	0.2	0.3	0.4	0.5	0.6	0.75	1
π										
0		0.46	0.5	0.56	0.56	0.58	0.58	0.6	0.62	0.62
0.1		0.52	0.52	0.56	0.58	0.58	0.58	0.62	0.68	0.72
0.2		0.58	0.6	0.62	0.64	0.68	0.72	0.76	0.78	0.8
0.3		0.64	0.66	0.68	0.72	0.74	0.78	0.84	0.84	0.84
0.4		0.7	0.7	0.72	0.76	0.78	0.82	0.86	0.86	0.86
0.5		0.74	0.78	0.8	0.82	0.82	0.86	0.88	0.88	0.9
0.6		0.9	0.9	0.9	0.9	0.92	0.94	0.96	0.96	0.96
0.75		0.94	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.98
1		1	1	1	1	1	1	1	1	1

Table 10: Pass rates (π altruism, δ inequality aversion)