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A tractable model of process fairness under risk

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A B S T R A C T

This paper proposes a social utility model of individual preferences for process fairness that complements the Fehr–Schmidt model for outcome fairness. The model assumes that the outcome generating process rather than the actual outcomes influences fairness perceptions, and that process fairness is evaluated through comparison of expected payoffs. The process model successfully predicts data from bargaining games involving risky payoffs that neither outcome-based nor reciprocity models can explain. In a theoretical application, Machina's parental example for non-expected utility in a distributional problem (Machina's Mom) is analyzed by incorporating individual level process fairness preferences under expected utility.

1. Introduction and outline

Consider a mother who has one son and one daughter, but only one candy. She is indifferent between giving the candy to either child, but, in apparent violation of expected utility, she strictly prefers to flip a coin to decide which child will receive the candy (Machina, 1989).[1] She accordingly flips the coin and gives the treat to the winning child, say the daughter. Her son complains that his sister receives a candy while he does not. The mother does not grant his complaint pointing out the procedure was fair.

The parental example illustrates two notions of fairness: the son considers *outcome* fairness. He is exclusive concerned with the final allocation of outcomes and does not take into account how these outcomes have been generated. The mother cares about *process* fairness. It is not the final outcomes that influence her fairness evaluation but how these outcomes have been achieved. Various dimensions of process fairness have been identified in the psychological literature. Some of these are defined independently of the process that determines the outcome, like respectful treatment or the opportunity to have

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[1] The mother is indifferent between the two outcomes of the coin flip and the expected utility of the coin flip is therefore equal to the (identical) utility of the outcomes.

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voice (Anand, 2001; Cohen-Charash & Spector, 2001; Tyler & Lind, 2000). In this paper we will be concerned with aspects of process fairness that refer to the outcome generating process.

Empirical research has shown the importance of both outcome and process fairness for individuals who evaluate their economic allocations. Perceived process and outcome fairness improve attitudes toward organizations and markets, increase job satisfaction, cooperation and trust, and reduce counterproductive work behavior and turnover intentions (Brockner, 2006; Cohen-Charash & Spector, 2001; Greenberg, 1990; Sondak & Tyler, 2007; van den Bos, Vermunt, & Wilke, 1997). In bargaining experiments with monetary payoffs, the fairness of outcomes and processes has been shown to influence the probability that an agreement is reached, and the nature of the agreed upon allocation (Bolton, Brandts, & Ockenfels, 2005; Cox, 2004; Gächter & Riedl, 2005, 2006; Roth, 1995).

To formalize the tradeoffs that individuals make between monetary payoffs and outcome fairness, and to include outcome fairness in models of decision making, *social utility functions* have been formulated in the psychological literature (Loewenstein, Thompson, & Bazerman, 1989; Messick & Sentis, 1985), and in the economics literature (Bolton, 1991; Bolton & Ockenfels, 2000; Charness & Rabin, 2002; Fehr & Schmidt, 1999). Fehr and Schmidt (1999) proposed a parsimonious parametric model of inequality aversion that explains data from a wide variety of social decision making experiments. Because of its efficient combination of empirical realism and analytical tractability, it has been among the most widely applied theories in the analysis of contracts and cooperation.[2]

Despite the empirical relevance of process fairness, there have been few attempts to formalize this fairness concept through social utility models and to complement existing models of outcome fairness. The aim of this paper is to propose a model of process fairness that is based on the Fehr–Schmidt social utility function for outcome fairness. Our goal is to obtain an operational and tractable way to incorporate process fairness into the formal analyses of social decisions. Many theoretical and empirical problems that have been analyzed within the Fehr–Schmidt framework may also be affected by preferences for fair processes. Complementing the outcome-based Fehr–Schmidt model by a process model therefore provides a unified framework for the analysis of outcome and process fairness.[3]

Uncertainty is crucial to our formalization of process fairness. Consider a job that requires 5 years of relevant work experience and an applicant who has only 1 year of experience. Then there is little uncertainty about the outcome of the application process. If the position instead requires passing a set of psychological tests, the outcome is uncertain a priori and the fairness of the scoring process becomes relevant to the applicant. Results in van den Bos (2001) confirm that uncertainty increases the importance of the decision process and therefore the importance of process fairness. The process fairness model that will be proposed in this paper assumes that there is some uncertainty about the outcomes of the process ex-ante.

To test the predictive power of the process fairness model we derive its predictions in an ultimatum game framework with random proposals. This game has been studied empirically, and the behavioral pattern observed in the literature is compared to the theoretical predictions of the process model, and also to the predictions of the outcome model and to those of intention-based reciprocity models (Cox, Friedman, & Gjerstad, 2006; Dufwenberg & Kirchsteiger, 2004; Falk & Fischbacher, 2006; Fehr, Kirchsteiger, & Riedl, 1993; Offerman, 2002; Rabin, 1993; Sutter, 2007). We will discuss which of the fairness models can best organize the experimental findings, and provide a first calibration of the process model through the existing data.

In a second application we study how the process fairness model can shed new light on a theoretical paradox in the non-expected utility literature. Machina's well known maternal example (Machina's Mom), introduced in the initial paragraph of this paper, illustrates a violation of expected utility in a distributional problem. The paradox will be analyzed within the Fehr–Schmidt framework, assuming that the children hold either selfish, outcome-based, or process-based fairness preferences. It will be shown that Machina's example can be interpreted as a situation where individual fairness preferences put constraints on the fairness norms implemented in an organization.

2. The process Fehr–Schmidt model

This section introduces a social utility model for process fairness that is based on the functional form of the Fehr and Schmidt (1999) model of inequality aversion. The Fehr–Schmidt model has been widely used to model preferences for outcome fairness because of its analytical tractability. Using its basic structure allows us to model process fairness in a similarly operational and tractable way.

2.1. The model

Let there be two agents A and B who face uncertainty about their payoffs. Let X denote the random variable from which agent A's payoff is drawn, with $E[X]$ its expectation. Y denotes the random variable from which agent B's payoff is drawn and $E[Y]$ its expectation. Let $x \in \mathbb{R}$ and $y \in \mathbb{R}$ denote the actual payoffs of agents A and B. Fehr and Schmidt (1999, p. 822) propose the following utility function, the *Outcome Fehr–Schmidt Model*, to account for outcome fairness preferences:

[2] Rohde (2009) provides a behavioral axiomatization of the Fehr–Schmidt model. She shows that the model is a special case of Schmeidler's (1989) rank-dependent utility model for decision under uncertainty. See Section 2 for further discussion of the properties of the Fehr–Schmidt framework.

[3] Bolton et al. (2005) sketch a process model on the basis of Bolton and Ockenfels's (2000) outcome fairness to explain empirical data. The model considers multiple fairness reference points, and a fair procedure can substitute for a fair outcome as a reference point.

$$U_A(x,y) = x - \alpha_A \max\{y - x, 0\} - \beta_A \max\{x - y, 0\} \quad (1)$$

with $0 \leqslant \beta_A < 1$ and $\beta_A \leqslant \alpha_A$. This utility function takes the agent's social preferences into account by reducing the utility of the final monetary payoff, x, in the case of unequal payoffs, i.e. $x \neq y$. That is, the model assumes a tradeoff between selfishness (x) and other-regarding motives ($y - x$ and $x - y$). The utility reduction is larger when the inequality is disadvantageous than when it is advantageous, because $\beta_A \leqslant \alpha_A$. From $\beta_A < 1$ it follows that the agent's utility is always increasing in her own payoff, and non-negativity of the parameters implies that there is no inequality seeking.

The outcome Fehr–Schmidt model is based on the intuition that individuals are willing to forgo monetary payoffs in favor of more equitable payoffs. The parametric assumptions introduce an egocentric bias in fairness evaluations that has been reported in empirical studies (Loewenstein et al., 1989; Messick & Sentis, 1979, 1985; Neugebauer, Perote, Schmidt, & Loos, 2009). Individuals are less willing to forgo payoff to reduce advantageous inequality than to reduce disadvantageous inequality.

The Fehr–Schmidt model explains a preference for fair outcomes regardless of how they were obtained. In many settings, however, agents care about the fairness of the process that generates and implements the outcomes (Brockner, 2006; Cohen-Charash & Spector, 2001; Frey & Stutzer, 2005; Sondak & Tyler, 2007; Tyler & Lind, 2000; van den Bos, 2001; van den Bos et al., 1997). Determinants of process fairness that have been identified in the empirical literature include the availability of equal chances and unbiasedness, the clarity of the allocation procedure, and consistency. Many psychological factors are potentially important for process fairness, but most of them cannot easily be formalized and measured to incorporate them in economic theory. We propose that in economic settings involving uncertainty, the agents' *expected* payoffs may be used as a measure of the fairness of the allocation process.

Expected payoffs will directly influence process fairness perceptions in many situations, and they can also serve as a proxy for other, more intangible determinants of fairness. An ambiguous selection process for promotions in an organization in combination with past experiences of favoritism may lead its members to hold lower payoff expectations than under a clear allocation process. Expected payoffs depend on payoffs in all potential states of the world and their respective probabilities. The actually experienced outcome is not evaluated independently of the generating process, contrary to outcome fairness.

To obtain a tractable formal model we therefore assume that agents evaluate the fairness of an allocation procedure involving uncertain outcomes by comparing expected payoffs. The following social utility function, the *Process Fehr–Schmidt Model*, accounts for preferences for fair payoff distributions by considering expected payoff differences between the agents:

$$U_A(x,X,Y) = x - \alpha_A \max\{E[Y] - E[X], 0\} - \beta_A \max\{E[X] - E[Y], 0\} \quad (2)$$

with $0 \leqslant \beta_A < 1$ and $\beta_A \leqslant \alpha_A$. This utility function takes the agent's social preferences into account by reducing the utility of the final monetary payoff in the case of unequal expected payoffs, i.e. $E[X] \neq E[Y]$. The model assumes a tradeoff between selfishness (x), and other-regarding motives that consider the process generating the outcomes of the individuals ($E[X] - E[Y]$ and $E[Y] - E[X]$). As in the final payoff model there is an egocentric bias and the utility reduction is larger when the inequality is disadvantageous than when it is advantageous. Now $\beta_A < 1$ implies that the agent's expected utility is increasing in own expected payoff. Non-negativity of the parameters implies that there is no inequality seeking in expected payoffs.

Note that the expectations refer to the payoff generating process and do not change if actual outcomes are determined.[4] The expected payoffs may be equal even if actual payoffs are unequal, and the different fairness concepts of the process model and the outcome model lead to different evaluations of identical outcomes, depending on the generating process. The value of an allocation (x, y) with $x \neq y$, drawn from random variables X and Y with equal expected value, is reduced because of inequality in the outcome model but not in the process model. This is particularly important in situations where no fair allocation of outcomes is possible. On the other hand, the value of an allocation (x, y) with $x = y$, drawn from random variables X and Y with unequal expected values, is reduced in the process model but not in the outcome model.

2.2. Discussion of theoretical assumptions

2.2.1. Equality norm

The Fehr–Schmidt models assume equality, in payoff or expected payoff, respectively, as the reference point for individual fairness evaluations. In many settings agents may deserve different expected payoffs, however. An employee who received high evaluations in the past would expect a higher chance for promotion than a colleague with low evaluations. In situations where the inputs of the agents differ, the inequality aversion terms in Eqs. (1) and (2) can be adjusted to account for allocations other than the equal split to be perceived as equitable. Boarini, Laslier, and Robin (in press) study a cross-country ultimatum game where the nominal exchange rate equal split of payoffs cannot explain behavior in terms of inequality aversion. Adjusting the fairness terms for real exchange rates, however, allows to explain the data in the Fehr–Schmidt framework. In general, where fairness perceptions deviate from equality, we can transform payoffs for the analysis such that equality becomes the fairness norm for the transformed units.

[4] The expected payoffs can be affected by the actions of the individuals, however, as illustrated in the discussion of the random ultimatum game in the next section.

2.2.2. Linearity

Payoffs and fairness are treated linearly in the current framework. The linearity assumption simplifies the analysis in many situations, but will not be valid in others. In some theoretical applications it will result in predictions of extreme outcomes. Nonlinear utility can be assumed in the Fehr–Schmidt framework to allow for a non-constant exchange rate between own payoffs and fairness (Fehr & Schmidt, 1999, p. 848). Rohde (2009) shows that the Fehr–Schmidt model is a special case of rank-dependent utility (Schmeidler, 1989), suggesting non-linear generalizations of the current framework.

2.2.3. Multiple comparisons

The process fairness model has been introduced in this section for the two-person case. It can easily be extended to the N-person case along the lines in Fehr and Schmidt (1999). A crucial assumption in the N-person case is that an agent compares her own expected payoff to each other agent's expected payoff. That is, in a three person situation an agent will discount her outcome utility if her expected payoff equals x and the other two persons have expected payoffs $0.5x$ and $1.5x$. Being better off in expectation than one person and being worse off than the other person both reduces her utility, although her expected payoff equals the group's average expected payoff. Empirical results reported in Ordóñez, Connolly, and Coughlan (2000) support the assumption of multiple comparisons assumed in the Fehr–Schmidt framework.[5]

3. Random ultimatum game predictions

This section derives the prediction of the process Fehr–Schmidt model in a bargaining game with risk and the next section discusses the experimental evidence. The game formalizes the idea that payoffs in a group production may deviate from equality (one person has to be first author of a paper to which each author contributed equally), and that team members have the possibility to affect the payoff distribution through conditional effort, selective communication of important information, or by putting aside resources. Greenberg (1990, 1993) demonstrates such counterproductive work behaviors in laboratory and field studies.

Another mechanism that influences the payoff distribution in joint production settings with uncertain individual payoffs is the option value of future cooperation. Low satisfaction with the outcomes due to perceptions of unfairness can lead participants to withdraw from the team and eliminate this option value (Hendrix, Robbins, Miller, & Summers, 1998; Jones & Skarlicki, 2003).

3.1. Definitions and notation

Consider the following *Random Ultimatum Game*: a random device proposes a partition of a pie of size 1 into a share x offered to a responder, and a share $1-x$ for a passive player. Before the proposal is randomly selected, the responder has to announce which offers she will accept and which she will reject. In case of acceptance of an actually selected offer, both players receive their proposed share. If the offer is rejected, both players receive nothing.

Let X denote the random variable from which the *offer* x is drawn. Let $F(x)$ denote its distribution function and $E[X]$ its expectation. Accordingly, $E[1-X]$ is the passive player's expected offer. We define a random proposal as *fair* if $E[X]=0.5$, and as *unfair* if $E[X]\neq 0.5$. The random process used to determine the offers is common knowledge.

The utility of a responder who applies the outcome Fehr–Schmidt model is

$$U(x)=x-\alpha\max\{(1-x)-x,0\}-\beta\max\{x-(1-x),0\} \tag{3}$$

The utility in the case of a rejection is normalized to be zero: in this case there is no payoff and no inequality.

Let $\widetilde{X}$ and $\widetilde{Y}$ denote the random variables from which the actual *payoffs* of the responder and the passive player are drawn conditional upon the announcement of the responder. These random variables are generated by the original offer distribution and possible rejections of the responder. The utility of a responder who applies the process Fehr–Schmidt model becomes

$$U(x,\widetilde{X},\widetilde{Y})=x-\alpha\max\{E[\widetilde{Y}]-E[\widetilde{X}],0\}-\beta\max\{E[\widetilde{X}]-E[\widetilde{Y}],0\}. \tag{4}$$

If the responder does not reject any offer, the expected actual payoffs are equal to the expected offers, i.e. $E[\widetilde{X}]=E[X]$ and $E[\widetilde{Y}]=E[Y]$.

It will be shown that in both models the responder's rejection behavior can be described by a threshold value, her *minimum acceptable offer* (hereafter MAO): all offers larger than the MAO are accepted, and all lower offers are rejected.

3.2. Predictions of the outcome model

In the outcome Fehr–Schmidt model the responder's utility can become negative for small offers. It is increasing in her own offer and always positive for shares larger than half of the pie (Fehr & Schmidt, 1999).

[5] The modeling framework of Bolton and Ockenfels (2000) and Bolton et al. (2005) assumes that people compare their own outcomes to the average of a reference group. In situations where only group averages are known, this framework may be easier to apply.

In this model the responder anticipates her ex-post utility of being offered a possibly unfair payoff share before the uncertainty is actually resolved. To maximize her expected utility in the random ultimatum game she will announce to reject all offers that give her negative utility and to accept those that give her positive utility ex-post, regardless of the underlying offer distribution $F(x)$. If a rejected offer is drawn, her actual utility will be zero. Since utility is always positive for advantageous inequality, we calculate the MAO (denoted as x_m) by considering only disadvantageous inequality and therefore maximizing $\int_{x_m}^{0.5}[x-\alpha(1-x-x)]dF(x)$ with respect to x_m. We obtain the expected utility maximizing MAO $x_m = \alpha/(1+2\alpha)$.

The MAO lies between zero and half of the pie, and is strictly increasing in α. For all subjects with $\alpha > 0$, i.e. for those who are not purely selfish, the MAO is strictly positive for all possible underlying offer distributions.

This threshold is identical to the one that Fehr and Schmidt (1999, p. 826) derive for decisions under certainty. A subject who evaluates fairness exclusively from the final outcome perspective announces the same positive MAO for both fair and unfair offer processes. The fairness of the generating process does not influence her fairness perceptions.

3.3. Predictions of the process model

In the outcome model, the MAO is determined by a comparison of each allocation $(x, 1-x)$ with the rejection allocation $(0, 0)$. In the process model, however, the ex-ante rejection of some allocations changes actual expected payoffs, and therefore fairness evaluations. In particular, by rejecting some unfair allocations ex-ante, the difference in expected payoffs is reduced, therefore increasing utility for all allocations experienced ex-post.

On the other hand, even if an advantageous allocation obtains, if the expected payoffs were not equal ex-ante the agent will experience a reduction in utility ex-post. Consider the example where a researcher has been selected by the head of the department to present a project during a prestigious conference. Knowing that she has only been selected because her colleagues who had been asked first were not able to attend will reduce her evaluation of this positive outcome.

Considering the effect of rejections on expected payoffs, we will distinguish three situations: equal expected offers, a higher expected offer for the responder, and a lower expected offer for the responder. The analysis will show that for equality and for advantageous expectational inequality no offers are rejected, implying a MAO of zero. In the situation of disadvantageous inequality we must consider two cases. In one case the responder is able to eliminate all expectational inequality by rejecting some offers. In the other case the inequality is not eliminated completely, because the cost to the responder in terms of absolute payoffs are too high. Rejecting some offers always reduces the responder's absolute payoff, and this reduction must be traded off against possible gains from increasing fairness.

First, consider a fair random offer process with $E[X] = 0.5$. Then the inequality aversion terms drop from the process Fehr–Schmidt utility function in Eq. (4) and the responder's utility becomes $U(x, \widetilde{X}, \widetilde{Y}) = x$. She will not reject any offer because otherwise her expected payoff will be reduced and expected advantageous inequality will be created. Thus for all levels of inequality aversion to expected payoff differences, the responder will announce a zero MAO.

Second, consider an advantageously unfair random process with $E[X] > 0.5$. Rejecting some of her advantageous offers, the responder can reduce the expected payoff difference $E[\widetilde{X}] - E[\widetilde{Y}]$: rejecting an advantageous offer strongly reduces her own expected payoff but only weakly reduces the expected payoff of the passive player.[6] Expected payoffs can then become equal at some point if advantageous offers are rejected. As we have seen, at this point she will not reject any more offers, and we therefore consider only the advantageous inequality aversion term in utility function Eq. (4) when calculating her expected utility.

As long as there is some difference in expected payoffs, the responder will experience a utility reduction for both accepted and rejected offers ex-post, that is, there will be an inequality aversion term in the utility function.[7] Letting D denote the set of accepted offers, the responder's expected utility becomes

$$\int_{x\in D}[x-\beta(E[\widetilde{X}]-E[\widetilde{Y}])]dF(x)+\int_{x\notin D}[0-\beta(E[\widetilde{X}]-E[\widetilde{Y}])]dF(x). \tag{5}$$

From the linearity of the utility and the linearity of the expectation it follows that this equals

$$\int_{x\in D}[x-\beta(2x-1)]dF(x)$$

and we observe that because of $\beta < 1$ expected utility is maximized by accepting all offers (see Appendix A). The loss in expected utility due to the rejection of any advantageous offer is larger than the gain from reducing expectational inequality. Intuitively, because rejected offers reduce both the responder's and the passive player's expected payoffs, under advantageous inequality all gains in fairness must come from stronger reductions in the responder's payoff. These reductions are weighted with a factor 1 for the absolute payoff term, but only with a factor $\beta < 1$ for the relative payoff term. Facing an advantageously unfair offer process the responder will therefore announce a zero MAO.

[6] For instance, announcing the rejection of the extreme allocation $(1, 0)$ reduces the agent's own expected payoff, but not the expected payoff of the passive player. It therefore also reduces the difference in expected payoffs.

[7] Only complete expectational equality eliminates the inequality aversion terms. Note also that the experienced disutility of process unfairness is independent of the actually experienced outcome.

Third, consider the situation of a disadvantageously unfair random process with $E[X] < 0.5$. If the responder announces a zero MAO, she will experience a utility reduction because of the expected payoff difference. Increasing her MAO somewhat, she can increase her expected utility if the marginal reduction in her own expected payoff is smaller than the marginal gain from reducing expected payoff differences. She will continue to increase the MAO until either of two cases obtains.

In the first case, by increasing her MAO at some point the marginal gain from reducing unfairness equals the marginal loss from own expected payoff reduction, but her expected payoff is still lower than the passive player's expected payoff. The optimal MAO therefore involves disadvantageous inequality in expected payoffs, and for all actual offers, whether they are accepted or rejected, she will experience a utility reduction. This optimal MAO can be calculated considering only the disadvantageous inequality term in Eq. (4) by maximizing the expected utility

$$\int_0^{x_m} [0 - \alpha(E[\widetilde{Y}] - E[\widetilde{X}])]dF(x) + \int_{x_m}^1 [x - \alpha(E[\widetilde{Y}] - E[\widetilde{X}])]dF(x) \tag{6}$$

with respect to x_m. Maximization gives $x_m = \alpha/(1+2\alpha)$: in this case where the responder does not eliminate expected disadvantageous inequality completely, the optimal MAO is identical to the one in the outcome Fehr–Schmidt model (see Appendix A).

In the second case, by increasing her MAO at some point the players' expected payoffs become equal, but the current MAO is still lower than the value $x_m = \alpha/(1+2\alpha)$. Because there are no more gains possible from increasing the MAO, this value is her expected utility maximizing MAO. The second case obtains if there is a solution x_m to the equation

$$E[\widetilde{X}] = E[\widetilde{Y}] \Longleftrightarrow \int_{x_m}^1 x dF(x) = \int_{x_m}^1 (1-x)dF(x)$$

that is smaller than $x_m = \alpha/(1+2\alpha)$.

Summarizing, a subject who evaluates fairness from the process perspective announces a zero MAO if she faces a fair offer process or an advantageously unfair offer process. For disadvantageously unfair offer processes she announces a MAO smaller or equal to $x_m = \alpha/(1+2\alpha)$, the optimal MAO for all processes under the outcome fairness perspective.

4. Random ultimatum game: Experimental evidence

Table 1 summarizes the random ultimatum game predictions of the process and the outcome Fehr–Schmidt model for the empirically relevant cases of fair and of disadvantageously unfair random offers. It also includes intention-based reciprocity models that predict zero MAO for all random offer processes: low offers cannot be interpreted as unkindness and the other player is therefore not punished by a rejection. The table assumes $\alpha > 0$.

4.1. Evidence

Experimental results indicate the empirical relevance of the pattern of rejections in fair and unfair random treatments predicted by the procedural fairness model. In a seminal article, Blount (1995) compared participants' MAOs in an ultimatum game with a real proposer and in an ultimatum game with a fair random proposal. She finds that responders who are willing to sacrifice significant amounts of money to avoid unfair outcomes in human proposer treatments, i.e. those for whom fairness considerations matter, accept very unfair offers in an a priori fair random proposal treatment. While less than 30% of the responders accept the smallest positive offer in the human condition, more than 80% accept these small offers if they come from a fair random draw. Offerman (2002) replicated the result in a slightly different game. He finds that 83% of his participants retaliate after an unfair offer made by a human proposer, but only 17% retaliate after an unfair random offer from an unbiased random device. These treatment effects stand in contrast to the predictions of the outcome Fehr–Schmidt model, but can be explained by the process model or reciprocity where unfair offers from fair random devices do not lead to negative fairness evaluations.

Cox and Deck (2005) study mini-ultimatum games where only two offers were possible. The offer was either an unfair allocation with \$2 for the responder and \$8 for the proposer or a fair split with \$5 for each player. In one treatment the offer was made by the proposer, in the other treatment it came from an equal chance random draw, implying unfair expected payoffs of \$6.50 for the proposer and \$3.50 for the responder. Twenty-one percent of the responders rejected the unfair offer coming from the proposer, and 23% rejected it under the unfair random allocation. That is, the unfair random offer elicits

Table 1
Predicted minimum acceptable offers for the random ultimatum game.

	Fair random offers $E[X] = 0.5$	Unfair random offers $E[X] < 0.5$
Outcome Fehr–Schmidt	MAO = $\alpha/(1+2\alpha)$	MAO = $\alpha/(1+2\alpha)$
Process Fehr–Schmidt	MAO = 0	$0 <$ MAO $\leqslant \alpha/(1+2\alpha)$
Intention-based reciprocity	MAO = 0	MAO = 0

equally strong negative evaluations as the intentionally unfair offer in this experiment. This is consistent with process fairness or outcome fairness but cannot be explained by intention-based reciprocity.

Bolton et al. (2005) compare human proposals with both fair and unfair random proposals within one mini-ultimatum game experiment. Responders could accept or reject an unfair allocation of 200 Spanish pesetas for themselves and 1800 for the proposer. The other two potential offers were the equal split of 1000 pesetas each, and an advantageously unequal allocation of 1800 for the responder and 200 for the proposer. In the fair random proposal the distribution over offers was symmetric. In the unfair random proposal the probability of the poor outcome was higher than the probability of the advantageous outcome, establishing an unfair procedure with an expected payoff difference of 1552 pesetas.

Bolton et al. report 41% rejections of the unfair offer in the human proposer condition. With unfair random offers, the rejection rate is somewhat lower at 34%, but not significantly different than in the human proposers condition. As in Cox and Deck, these rejections of unfair random offers cannot be explained by intention-based reciprocity. Comparing unfair random offers with fair random offers, Bolton et al. find a significant reduction with only 19% rejections of fair random offers as predicted by process fairness. Also consistent with the predictions of the Fehr–Schmidt process model they find almost no rejections of equal outcomes or advantageously unequal outcomes (less than 10%).

A variation of the random ultimatum game has been studied by Bolton and Ockenfels (2008). Participants in this study made binary choices between risky and safe social allocations of money for themselves and another (passive) person. Risky allocations of type I led to equal outcomes in each uncertain event, risky allocations of type II led to unequal outcomes in each event. Both types of risky allocations led to equal expected outcomes for the decision maker and the passive player. A generic set of matched decision problems is shown in Table 2.

In Table 2 the social utilities of the allocations are calculated for the outcome and the process Fehr–Schmidt model. Under the outcome model risky allocations of type II yield lower utilities than the type I allocations in each uncertain event. Under the process model type I and type II risky allocations are equivalent. The safe allocation yields identical utilities under the outcome and the process model because there is no uncertainty in the process, and therefore expected payoffs equal actual payoffs.

In various decision problems Bolton and Ockenfels find that the percentage of risky choices in decisions between safe and risky I allocations was equal to the number of risky choices in decisions between safe and risky II allocations. This indicates that, in violation of the outcome model, participants did not perceive risky allocations of type II as inferior to risky allocations of type I. Under outcome fairness, fewer risky type II than risky type I choices should be observed. Process fairness, however, is consistent with equal acceptance rates of risky I and risky II social allocations. These results support the process fairness model and they show that process fairness effects can also be observed if a risky decision frame is applied instead of a divide-the-pie frame.

4.2. A calibration

Numerous empirical studies have established the importance of outcome fairness and reciprocity for economic decision making. Fewer studies have looked into the role of process fairness. The above discussed studies have shown that apart from outcome fairness and intentionality, process fairness is another economically relevant factor in social preferences and that the process model successfully explains the observed empirical pattern in the random ultimatum game.

Future research on the empirical relevance of process fairness could proceed into three directions. First, in the program that studies the relative importance of outcome fairness and reciprocity (Brandts & Sola, 2001; Charness, 2004; Falk, Fehr, & Fischbacher, 2008), process fairness can be included as a third factor. Its weight in fairness evaluations can be assessed in settings that allow us to discriminate between the three motives, as in the rightmost column in Table 1. Second, different models of process fairness may be empirically compared to assess the validity of their diverging theoretical assumptions. Third, process fairness models should be calibrated, and their consistency be evaluated across various decision situations (Blanco, Engelmann, & Normann, 2008).

Although the above discussed empirical studies were conducted to examine the qualitative effects of (fair or unfair) unintentional processes, we can derive some quantitative calibration of the process model and of the weights of the different fairness motives from the two studies that include unfair random processes.

First consider the bounds for the inequality aversion parameter α. In Cox and Deck (2005) the rejection of the unfair offer makes the expected payoffs equal and therefore allows for the identification of the parameter α from the preference *U*(accept

Table 2
Social allocations under risk (Bolton & Ockenfels, 2008).

	Safe	Risky I	Risky II
(Random) allocations	(€7, €7)	[(€16, €16), 1/2; (€0, €0)]	[(€16, €0), 1/2; (€0, €16)]
Outcome Fehr–Schmidt[a]	7	[16, 1/2; 0]	[$16 - 16\beta$, 1/2; -16α]
Process Fehr–Schmidt[a]	7	[16, 1/2; 0]	[16, 1/2; 0]

Note: (€*x*, €*y*) denotes an allocation of €*x* to the decision maker and €*y* to the passive player. [(€*x*, €*y*), 1/2; (€0, €0)] denotes a gamble that gives allocation (€*x*, €*y*) with probability 1/2 and allocation (€0, €0) with probability 1/2.

[a] Allocations replaced by the respective social utilities. Decision maker chooses between safe and risky I or between safe and risky II.

all) = $2-3\alpha <$ U(reject unfair) = 0. Rejection implies $\alpha > 0.67$, and 23% of the subjects show such behavior. Similarly, from rejections in Bolton et al. (2005) we can calculate that for 34% of the subjects $\alpha > 0.13$. Comparing these levels of disadvantageous inequality with those calibrated by Fehr and Schmidt (1999) and Blanco et al. (2008) for outcome fairness suggests that α's are smaller for process fairness. Blanco et al., for instance, find that 69% of the subjects have $\alpha > 0.4$ and still 36% have $\alpha > 0.92$. Note, however, that calibrations of outcome fairness parameters include both outcome fairness and reciprocity motives. A rejection in the ultimatum game may be driven by either outcome motives or intention-based reciprocity motives. In contrast, our calibration of the process model from unintentional but unfair random processes excludes reciprocity.

Bolton et al. compare rejection rates for the same game under human proposers, unfair random proposals, and fair random proposals. From their data we can calculate lower bounds for the shares of subjects with different fairness motives.[8] Under fair random proposals 19% of the subjects reject the unfair outcome. These rejections cannot be caused by process or reciprocity motives. That is, at least 19% of the people put at least some weight on outcome fairness; this does not exclude the possibility that they also consider other fairness motives.

For unfair random processes, 34% rejected the unfair allocation. That is, at least 15% (i.e. 34–19) reveal pure process fairness: reciprocity does not apply in random proposals and they do not reject if the random process is fair. Comparing human proposals and unfair random proposals, we find that at least 7% (i.e. 41–34) of the subjects hold pure reciprocity preferences. If both outcome and process are unfair, they do not reject outcomes as long as no intentional act by a human proposer is involved.

Calibration of Bolton et al.'s results shows that for each of the three fairness motives, a significant share of people holds this motive purely. There is no reason, however, to assume that people will not consider mixed motives, or put different weights on either motive depending on the situation. If the process if fair, the subject may pay more attention to fair outcomes. This effect may complicate cross situation prediction at the individual level. If the models capture the most relevant motives in a certain setting, however, aggregate behavior can still be predicted correctly across settings as shown by Blanco et al. (2008).

5. Understanding Machina's Mom: Process fairness in an expected utility paradox

Machina (1989) gave the example of a mother who has a single indivisible item that she can either give to her daughter Abigail or to her son Benjamin. She is indifferent between giving the treat to either child and strictly prefers both situations to that where neither child receives the item. However, in seeming violation of expected utility theory, the mother strictly prefers a fair coin flip over either sure allocation of the item (and over any unfair random allocation). Her preferences over allocation processes are summarized in Fig. 1.

Assume that there is no positive utility of gambling involved and that the children have to accept any decision made by their mother. Given that the mother is indifferent between giving the item to either child for sure, it seems difficult to explain her strict preference for randomization.

In this section we will provide a explanation of the *mother's* preferences in terms of other-regarding preferences *of her children*. That is, we assume the mother cares about her children's utilities, but we do not impose any fairness motives for the mother. The children's utilities depend on the fairness of the outcomes or the process, however, making the mother's preference dependent on these fairness motives. Below we will argue that incorporating fairness at the children's level provides a foundation for fairness in situations structurally similar to the stylized Machina's Mom problem, and allows for applications in settings where fairness should enter in a "bottom up" fashion.

Let V denote the mother's utility and let U_A and U_B denote her children's utilities. The mother's utility is a function of her children's utilities, $V(U_A, U_B)$, and her utility is increasing in both arguments. Consider three cases for the children's preferences: her children are selfish (normalize $U_i(0) = 0$ and $U_i(1) = 1$), care about outcome fairness (Eq. (1)), or care about process fairness (Eq. (2)). For each case and each allocation procedure P, Q, R, and S, Table 3 shows the utilities of Abigail and Benjamin (U_A, U_B).

We observe that if the mother is indifferent between Q and R, a preference for the gamble P over the sure allocations Q or R cannot be explained if her children are selfish or inequality averse in final outcomes. In the selfish case we have $V(1,0) = V(0,1)$ because the mother is indifferent between Q and R, and the gamble P is therefore not preferred. The children only care about their own payoff and, thus, randomization does not make anyone better off. In the outcome inequality aversion case, we have $V(1-\beta, -\alpha) = V(-\alpha, 1-\beta)$ and again the gamble P is not preferred. The child that does not receive the item will inevitably start weeping both with or without randomization.

If her children apply the procedural view on fairness, however, a choice of P over both Q and R is rational under expected utility. The mother is indifferent between giving the item either to Abigail or to Benjamin directly, and her utility is increasing in both children's utility. Therefore $V(-\alpha, 1-\beta) = V(1-\beta, -\alpha) < V(1,0) = V(0,1)$.

Under expected utility the mother will prefer the gamble P over either of the sure allocations Q and R. While the mother appears to violate expected utility if we describe her outcomes as (A, B) = (Abigail receives the item, Benjamin receives the

[8] The discrete nature of their game does not allow to distinguish subjects who do not care about fairness at all from those who have weak preference for fairness and would possibly reject more extreme allocations. The percentages form lower bounds for fairness preference therefore.

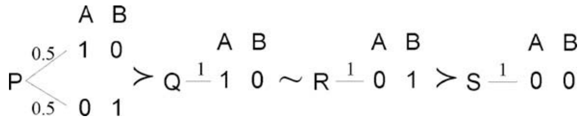

Fig. 1. Mother's preferences in Machina's parental example (Machina's Mom).

Table 3
Children's utilities under different fairness preferences.

	P	Q	R	S
Selfish	$[(1, 0), 1/2; (0, 1)]$	$(1, 0)$	$(0, 1)$	$(0, 0)$
Outcome F–S	$[(1-\beta, -\alpha), 1/2; (-\alpha, 1-\beta)]$	$(1-\beta, -\alpha)$	$(-\alpha, 1-\beta)$	$(0, 0)$
Process F–S	$[(1, 0), 1/2; (0, 1)]$	$(1-\beta, -\alpha)$	$(-\alpha, 1-\beta)$	$(0, 0)$

Note: (x, y) denotes the allocation of x for Abigail and y for Benjamin. $[(x, y), 1/2; (z, w)]$ denotes a gamble that gives allocation (x, y) with probability 1/2 and allocation (z, w) with probability 1/2.

item), she does not violate expected utility if we incorporate procedural fairness preferences of her children and describe her outcomes as (U_A, U_B). Process fairness can explain the expected utility paradox.[9]

By incorporating fairness at the children's level, we obtain a utility function $V(A, B, f(A, B))$ for the mother that does incorporate fairness. We may call this utility function a reduced form of the above two-level utility with fairness entering only at the lower (children) level. Empirically such a reduced form would be indistinguishable from the two-level model. Modeling fairness through self-centered individual fairness preferences of the agents who are actually affected by an allocation might be preferred to a reduced form modeling for two reasons.

First, self-centered preference models as in the Fehr–Schmidt framework have been extensively studied under incentive compatible conditions. Preference models can be estimated and refined, providing a sound individual level foundation for fairness in allocation problems.

Second, and maybe more importantly, in many real world applications the individual fairness preferences form a constraint for the possible allocation processes employed by the allocating entity. Reinterpreting the mother's problem as an organizational allocation problem illustrates the problem. The organization may be strongly committed to outcome fairness, preferring allocation S over either Q and R, leading to zero surplus. If the individual agents have process fairness preferences, however, a positive surplus could have been implemented by fair randomization. Vice versa, committing the organization to process fairness will lead to utility losses if agents hold the outcome view on fairness.

More generally, individual fairness preferences can provide a foundation for organizational fairness norms where this norm is not obvious or is difficult to justify otherwise (Frohlich, Oppenheimer, & Eavey, 1987; van Winden, 2007). Complementing the outcome Fehr–Schmidt framework by a process model allows for a more complete analysis of such allocation problems and for the consideration of allocations that would be excluded under a pure outcome perspective. In Machina's example we can justify a strict preference for randomization even if both sure allocations Q and R are equally preferred and lead to negative utility for at least one child. If the children accept process fairness, randomization leads non-negative utility for both children.

6. Discussion

We have introduced a unified framework for process and outcome fairness in situations where final payoff allocations can be uncertain. The model builds on the Fehr–Schmidt social utility theory for outcome fairness that has been applied successfully in empirical and theoretical work on financial decisions with social comparisons (Gebhardt, 2005), contract theory (Englmaier & Wambach, 2005; Fehr, Klein, & Schmidt, 2007), and preference aggregation in groups (Trautmann, in press). These applications involve decisions under uncertainty and, apart from outcome considerations, process fairness becomes potentially important.

Process fairness is modeled through expected payoff differences in this paper. This maintains the tractability of the model and serves as a good approximation in many economic settings. Expected payoffs are comparable across situations and people, and the Fehr–Schmidt utility functions can easily be assessed empirically (Abdellaoui, 2000; Abdellaoui & Bleichrodt, 2007; Camerer & Fehr, 2004; Rohde, 2009).

The theoretical analyses in this paper suggest new empirical questions. With both the outcome and process perspective on fairness potentially influencing decisions, it can be studied which factors strengthen either fairness view. The importance of perceptional factors and framing of information has been suggested by results in van den Bos et al. (1997): If information

[9] If her children consider both outcome and process fairness, the mother's strict preference for P would also obtain. Because under outcome fairness the mother is indifferent between P and Q and R, we always need some weight on process fairness to justify strict preference. Note that under strong outcome fairness preference, S might be preferred to P, Q and R. Such a preference is excluded in Machina's problem by assumption.

about the process precedes information about outcomes, fairness perceptions are more strongly influenced by the fairness of the process than the fairness of the outcomes, and vice versa. Emotions and affect influence economic decisions and bargaining behavior (Ben-Shahkar, Bornstein, Hopfensitz, & van Winden, 2007; Bosman, Sutter, & van Winden, 2005; Loewenstein, 1996; Rubaltelli & Slovic, 2008), and they suggest themselves as potential factors in outcome versus process fairness evaluation.

For different strategic settings involving risk, fairness effects can be decomposed into process, outcome, and reciprocity components as shown in Section 4.2. The three components may receive different weight in different situations, and we can measure their monetary impact across economic settings. A taxonomy can be developed of situational factors that influence which component has the strongest impact on behavior.

Consistency of preferences in dynamic settings has been an active topic in intertemporal choice and decision under uncertainty (Cubitt, Starmer, & Sugden, 2004; Loewenstein & Prelec, 1992; Machina, 1989; Sarin & Wakker, 1998), leading to theoretical innovations and new applications. Studying the consistency of fairness perspectives in dynamic settings may similarly offer new insights into the structure of interdependent preferences and empirical problems.

Formal models of fairness preferences help to highlight theoretical properties, and they allow the inclusion of these preferences into theories of strategic and group decision making. A limitation of the formal approach is, however, that the model is only an approximation of the true mechanisms and that some relevant psychological factors influencing fairness preferences might not be easily included in the model. Psychological accounts of fairness will describe mechanism more accurately, but will often be less structured. A combination of both approaches seems warranted therefore if we want to study the impact of fairness in economic decisions.

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Appendix A. Optimal MAOs in the process Fehr–Schmidt model

For an advantageously unfair random process the responder's expected utility in the process model is

$$\int_{x\in D}[x-\beta(E[\widetilde{X}]-E[\widetilde{Y}])]dF(x)+\int_{x\notin D}[0-\beta(E[\widetilde{X}]-E[\widetilde{Y}])]dF(x),$$

where D is the set of all offers she announces to accept. This can be rewritten as

$$\int_{x\in D}xdF(x)-\beta\int_0^1(E[\widetilde{X}]-E[\widetilde{Y}])dF(x)=\int_{x\in D}xdF(x)-\beta\int_0^1\int_{z\in D}(z-(1-z))dF(z)dF(x)=\int_{x\in D}[x-\beta(2x-1)]dF(x),$$

and is maximized by accepting all offers, thus announcing zero minimum acceptable offer.

For a disadvantageously unfair random process the responder's expected utility in the process model is

$$\int_0^{x_m}[0-\alpha(E[\widetilde{Y}]-E[\widetilde{X}])]dF(x)+\int_{x_m}^1[x-\alpha(E[\widetilde{Y}]-E[\widetilde{X}])]dF(x).$$

This can be rewritten as

$$\int_{x_m}^1 xdF(x)-\alpha\int_0^1(E[\widetilde{Y}]-E[\widetilde{X}])dF(x)=\int_{x_m}^1 xdF(x)-\alpha\int_0^1\int_{x_m}^1(1-z-z)dF(z)dF(x)=\int_{x_m}^1[x-\alpha(1-2x)]dF(x).$$

Optimizing with respect to x_m we obtain $x_m-\alpha(1-2x_m)=0$ implying the expected utility maximizing MAO $x_m=\alpha/(1+2\alpha)$.

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