Non-additivity and the Salience of Marginal Productivities:
Experimental Evidence on Distributive Fairness

BY URS FISCHBACHER†,‡, NADJA KAIRIES-SCHWARZ†† and ULRIKE STEFANI†
†University of Konstanz  ‡Thurgau Institute of Economics  ††University of Duisburg-Essen

We investigate the relevance of different distributive fairness norms in a team production process in which the team members’ contributions to the joint output are not necessarily additive. In some of the cases of non-additivity, the individual marginal contributions to the output are not salient. We vary the salience and investigate how third parties allocate the joint output to the team members. We find that the prevalent norm is to hold others responsible only for their inputs rather than for the incremental increase in the output. The marginal productivities are taken into account only when they are made readily apparent.

INTRODUCTION

In practice, situations in which the members of a team or a group must individually exert some effort or make relationship-specific investments to realize a joint output or profit are abundant. Real-world examples include work teams within a firm, business partnerships, corporate networks, strategic alliances of companies, research collaborations and co-authored publications. In these situations, mutually agreed-on ‘fair’ rules determining the ex post allocation of the joint output are an important mechanism to provide ex ante the team members with sufficient (monetary) incentives and to avoid costly renegotiations. In this context, the degree to which the marginal productivities are readily observable not only determines the type of performance measure that is available to create sufficient pecuniary incentives but also can affect the relevance of different norms of distributive fairness.

The experimental evidence for situations where the team members’ marginal productivities are observable indicates that the importance of distributive fairness norms is highly context-dependent (for a survey, see Karagözoglu 2012). However, one efficient compensation scheme in the case where a team member’s individual performance is observable is an allocation that takes into account the marginal productivities, effort levels or inputs (Alchian and Demsetz 1972). Usually, however, joint production processes are more complex. For the majority of workers, the individual performance within the team can be hard to observe (Prendergast 1999). In the cases in which the individual inputs and the marginal contributions are difficult to verify, the team members are frequently remunerated by means of a predefined fixed share of the joint output (i.e. by implementing some kind of ‘profit sharing’). Thus the performance measure does not directly depend on the individual marginal contributions. In practice, equal sharing is often referred to as a normatively appealing allocation rule (see, for example, Ashlagi et al. (2012) and the examples cited therein).

However, there are numerous joint production situations in which—although the inputs and their consequences for the joint output are observable—the individual marginal contributions are not salient due to the non-additivity of the individual inputs. As an example, Croson et al. (2004) describe a number of mergers and acquisitions that resulted in both synergies and negative externalities. In these cases, companies or teams often agree ex ante to equally share the potential future profits. An example for the
implementation of equal sharing is the joint venture (named Caradigm) formed by Microsoft and General Electric as a collaboration in the healthcare sector. Microsoft contributed various patented software technologies (Amalga, Vergence) to the joint venture, while General Electric provided a huge clinical database (Qualibria). However, it remains unclear whether equal sharing provides a sufficient performance incentive ex ante, as the inputs may not necessarily be symmetric in the sense that one input increases the output whereas the other does not. Moreover, even in the symmetric case in which both inputs increase the output, the marginal productivities may not necessarily be additive. For example, if skills in a joint venture are complementary, then the marginal productivities are super-additive. In these situations, it is questionable whether an equal profit-sharing rule is considered as fair and therefore is ex ante efficient. Moreover, it is not clear whether the group members should be remunerated according to their inputs or to their not necessarily additive marginal contributions to the joint output.

Although such joint production examples are numerous, there is no systematic investigation of the question of how the additivity and the salience of the marginal productivities affect the relevance of the different norms of distributive fairness. To the best of our knowledge, only a few studies in this strand of literature take into account the observability and thus the complexity of the production process. In Gächter and Riedl (2005) and in Karagozolu and Riedl (2014), the claims in the bargaining stage are based either on the relative or on no performance information. In Gantner and Kerschbamer (2013), the subjects’ inputs depend on their relative performance. The fact that the inputs enter a non-linear production function makes it more difficult to assess the individuals’ marginal contributions. We argue that although the information on the marginal contributions is often available, they are not necessarily salient because the inputs are often non-additive. Moreover, these studies focus on the question of whether the team members’ subjective claims influence the bargaining stage; in contrast, we are interested in the distributive fairness norms that are applied in this situation.

The aim of this study is to investigate distributive fairness in production situations in which the relative inputs are observable. However, the marginal productivities can be additive but can also lead to synergies or to negative externalities, and may consequently not be readily apparent. In particular, we are interested in the question of when an equal allocation of the joint output is perceived as fair regardless of the inputs and the marginal contributions, when the inputs are considered, and when the marginal increases resulting from the inputs are taken into account. More precisely, we investigate whether and how the salience of the marginal contributions affects distributive fairness.

In our experiment, we use a joint production process in which two team members have to answer a knowledge question to increase the output that is available for distribution. We vary the increase in the joint output that results from each team member’s correct answer. This procedure allows us to investigate whether the individual inputs (i.e. giving the right answer per se) or the marginal productivities (i.e. the increase in points realized by giving the correct answer) affects the distributional choices. For each treatment condition, we observe the distributional choices made for nine different production situations. In each of these nine situations, we showed the participants a payoff matrix with a joint output that was realized conditional on the four possible outcomes of the quiz. Of the nine situations, three situations were additive, three allowed for synergies, and three allowed for negative externalities. Hence the individual marginal productivities were noticeable, but not always salient.

Similar to Konow et al. (2009), a subject in the role of a third party decided how to allocate the joint output to the two team members. This procedure allows us to analyse
the norms of distributive fairness in a clean and unbiased fashion—abstracting from issues like self-centred fairness or self-serving behaviour. As it might be important how saliently the marginal contributions are presented, we implemented as a baseline treatment a simultaneous framing in which we showed the participants only the nine payoff matrices. In order to increase the salience of the marginal contributions, we additionally implemented two sequential framing treatments. In one of them, we presented the payoff matrix in a way that showed the production outputs resulting if both of the subjects gave the wrong answer, then if one subject was right, then if the other subject was right, and then if both were right. Thus it was clear that a person increased the payoff from one output to a higher output, but because the difference between the outputs was not explicitly shown, the subjects could easily ignore it. In the other sequential treatment, we showed the marginal output increases caused by giving the correct answer instead of the payoff matrix.

Our results indicate that the third parties predominantly held others responsible for their inputs (i.e. for answering a knowledge question either right or wrong). In the symmetric cases in which both subjects either knew or did not know the correct answer, the third parties distributed the output equally. In the asymmetric cases (i.e. only one of the team members answered the question correctly), the third parties allocated more points to the subject who knew the right answer. The predominance of the distribution norm accounting for the individual inputs is robust to the additivity of the marginal output increases, to the question of whether the third parties were completely external or a member of another team, and the framing of the production process (simultaneous vs. sequential). Although all of our framings are economically equivalent, subjects consider the marginal productivities only if they are made salient.

This paper proceeds as follows. Section I presents the design of our experiment, and Section II derives the predictions for the distributive fairness norms that we consider. Section III presents the results of our experimental study. Section IV summarizes our key findings and offers concluding remarks.

I. EXPERIMENTAL DESIGN

The focus of our experiment is on the distribution of a joint output that has been produced within a group of two subjects, A and B. In each of our treatments, we implemented nine different production matrices with four outcomes each, depending on whether none, one, or both subjects within the group made an input to the joint output. The novelty of the design is that the output of the production task can either be additive or lead to positive or negative externalities. In all of our treatments, the experiment consisted of a production stage within a team of two subjects, and a distribution stage in which a third party allocated the joint output to the team members. We used the strategy method (Selten 1967). Thus the subjects first made their distribution decisions for all nine payoff matrices and all four possible outcomes within a matrix. Then production took place, and two matrices were chosen for being payment relevant. We describe first the production task and then the design of our treatments.

Description of the production task

Similar to Gächter and Riedl (2005, 2006), Luhan et al. (2013), Karagozoglu and Riedl (2014), and Gantner and Kerschbamer (2013), the subjects’ production task was to answer multiple-choice questions from a knowledge quiz. In our design, the subjects
jointly produced by answering one knowledge question each. The input of giving the right or wrong answer determined the subjects’ total contribution to the joint output achieved within a group of two team members. The experimental software randomly chose the question to be answered from a set of different questions.

The output of the production task was determined by whether neither subject A nor subject B, only subject A, only subject B, or both of the subjects within a group knew the correct answer to this question. The joint production output increased if one of the group members answered the question correctly, and it was highest if both subjects knew the correct answer. We kept the joint output in the symmetric cases in which neither or both of the subjects within the group knew the correct answer constant at 20 points and at 100 points, respectively. For the asymmetric cases in which only one of the participants gave the right answer, we varied the joint output to 30, 60 and 90 points. As illustrated in Table 1, there are thus nine different production payoff matrices, which we denote by

\[ JP_m \begin{pmatrix} 20 & A_r B_w \\ A_r B_w & 100 \end{pmatrix} (\text{with } m = 1, \ldots, 9). \]

\( A_r B_w (A_r B_w) \) refers to the asymmetric case in which subject A (subject B) gives the wrong answer to the question, whereas subject B (subject A) gives the right answer.

Because our variation of the joint production payoffs allows for a clear differentiation between varieties of marginal productivities, we can test whether the (exogenously given) increase in the joint output resulting from one of the group members answering the question correctly affects the distributional choices.

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**Table 1**

**Joint Production Payoff Matrices (Payoffs in Points)**
Note that the marginal production payoffs are additive only in the matrices

\[
JP_3 \begin{pmatrix} 20 & 90 \\ 30 & 100 \end{pmatrix}, \quad JP_5 \begin{pmatrix} 20 & 60 \\ 60 & 100 \end{pmatrix} \quad \text{and} \quad JP_7 \begin{pmatrix} 20 & 30 \\ 90 & 100 \end{pmatrix}.
\]

In these matrices, the marginal productivities in all three cases \(A_r B_w, A_w B_r\) and \(A_r B_r\) are evident: when the participants give the correct answer, the individual effects on the size of the distributable output are precisely determinable. The matrices

\[
JP_1 \begin{pmatrix} 20 & 30 \\ 30 & 100 \end{pmatrix}, \quad JP_2 \begin{pmatrix} 20 & 60 \\ 30 & 100 \end{pmatrix} \quad \text{and} \quad JP_4 \begin{pmatrix} 20 & 30 \\ 60 & 100 \end{pmatrix},
\]

in contrast, are super-additive, i.e. \(100 > 20 + (A_w B_r 20) + (A_r B_w 20)\). Because the group members' marginal productivities add up to less than 80 points, the subjects can realize synergy effects if they both know the right answer. It is thus not apparent which of the group members played the more decisive role in earning the joint output of 100 points. However, if only one group member answers correctly, then the resulting effect on the joint output again is precisely attributable. The matrices

\[
JP_6 \begin{pmatrix} 20 & 90 \\ 60 & 100 \end{pmatrix}, \quad JP_8 \begin{pmatrix} 20 & 60 \\ 90 & 100 \end{pmatrix} \quad \text{and} \quad JP_9 \begin{pmatrix} 20 & 90 \\ 90 & 100 \end{pmatrix}
\]

are sub-additive, because the sum of the individual marginal productivities exceeds 80 points. Given that one of the subjects knows the right answer, the other group member thus creates negative externalities on the joint production payoff by also giving the correct answer. We included the non-additive matrices in our design to investigate whether (and how) synergy effects and negative externalities affect the distributional choices. In particular, we can test whether the marginal productivities are more relevant for the additive matrices (in which the marginal productivities are more apparent) than for the non-additive matrices.

**Treatments**

In our baseline *third party treatment* (TPT), we assess the relevance of different distributive fairness norms applied by third parties who are not involved in the production process (see Konow *et al.* 2009).\(^7\) We implemented a design in which 50% of the subjects in each session were joint producers and in the role of the team member either A or B. We randomly chose one A and one B to form a group. 50% of the subjects were in the role of a third party C, i.e. they were not a member of the group of joint producers. First, the subjects in the role of C distributed the joint production payoff of the group members A and B for all of the four possible outcomes of each of the nine possible payoff matrices (see Table 1). Then the experimental software randomly determined two of the nine matrices as payoff-relevant. For each of these two matrices, we randomly built groups of one third party C and a group of two subjects in the roles of A and B. Each of the group members A and B had to answer one question in the role of A and one question in the role of B.\(^8\) The correctness of the answers of the two subjects A
and B determined the outcome realized (i.e. a specific cell of the randomly chosen payoff matrix). The joint output always increased by answering correctly. At the time when the participants A and B answered the question, they knew which matrix was payoff-relevant, but we had not yet informed them with whom they were paired in a group, whether or not this subject had answered the question correctly, and which distribution of the joint production payoff subject C had determined. The subjects C received a lump sum payment of €17.50 ($19.63). The subjects A and B were paid for the two randomly selected matrices and according to the outcome realized by answering the knowledge question, once as A and once as B. As and Bs received the share of the realized output determined by the decision of the subject C with whom they were matched. Because the subjects C decided how to allocate the output of an anonymous group, and because their choices did not affect their own payoffs, self-interest should not have affected their judgments. Thus this treatment enables us to observe the relevance of the norms of distributive fairness that are not distorted by self-serving behaviour or self-centred fairness norms.

In a variation of the baseline treatment (TPT), we implemented a role reversal treatment in which the subjects experienced both roles, A/B and C (TPT2R). In the distribution stage, the participants were third parties, and they were producers answering knowledge questions in the production stage. To ensure neutrality in the distribution stage, we built groups of three subjects A, B and C for each of the two payoff-relevant matrices. In particular, the distribution of a subject in the role of C was never relevant for the own producing group, but was relevant for two other producing subjects A and B. This treatment allows us to check whether making decisions in both roles affects the distributional choices.

Because the marginal productivities were observable but not readily apparent in the baseline treatment TPT and in treatment TPT2R, we also designed two conditions with a sequential framing. In one treatment, called TPTSQNM, we implemented a framing with a sequential display of the joint output realized if neither A nor B / only A / only B / both A and B knew the correct answer, but we did not make the marginal contributions explicit. Thus the subjects were informed about the total output that was produced if the question was answered correctly. In the other treatment, called TPTSQM, we made the marginal contributions very explicit. For the payoff matrix 1, for example, the subjects in treatment TPTSQNM were informed that the correct answer of A increased the output to 30 points, and after that, the correct answer of B increased the output to 100 points. In treatment TPTSQM, in contrast, the subjects were informed that the correct answer of A increased the output by 10 points, and after that, the correct answer of B increased the output by an additional 70 points. Thus while the marginal contributions were implicit in the sequential move structure in treatment TPTSQNM, they were explicit and very salient in treatment TPTSQM. Comparing treatments TPT2R and TPTSQNM allows us to investigate whether an implicit sequential framing of the marginal productivities affects the distributional choices, and comparing treatments TPTSQM and TPTSQNM allows us to isolate the effects resulting from the sequential framing from those resulting from the salience of the marginal productivities. For both TPTSQM and TPTSQNM, we implemented the same procedure as with TPT2R, except for the framing. For an example of the two procedures, see Appendix: Example TPTSQM.\textsuperscript{9}
Experimental protocol

Using ORSEE (Greiner 2004), we recruited students from the University and the University of Applied Sciences of the same town for our experiment. Each subject participated in only one of our sessions. We programmed and conducted the experiment using the z-Tree software (Fischbacher 2007).

As soon as all of the subjects of a session had entered the laboratory, they were seated at individual computer workstations. The participants received the instructions for their respective roles, which we asked them to read carefully. To ensure that all of the participants understood the rules of the game, the subjects had to answer some control questions. The experiment began after we had orally summarized the instructions to ensure common knowledge of the procedure.

At the end of the experiment, we converted the points that the subjects had earned into money (one point was equivalent to €0.25 ($0.28)) and paid out this amount together with the participation fee of €5 ($6.61). Table 2 shows the number of subjects per treatment as well as the average payments that the participants earned for a session of approximately 50 minutes. The compensation that the participants received is well above the hourly rate for student jobs.

II. Predictions

Equal sharing

The third parties could distribute the joint output equally to the team members, regardless of their inputs or their marginal productivities. According to the norm of equal sharing, A and B should each receive a share of 50% of the joint output, irrespective of who has answered the question correctly and has thus increased the distributable endowment.

This allocation is in line with the fairness ideal of strict egalitarianism according to Nielsen (1985). It leads to predictions that are identical to those based on equal sharing as modelled in Fehr and Schmidt (1999) and Bolton and Ockenfels (2000), because giving an answer to our knowledge quiz does not cause monetary effort costs.

Distribution based on the individual inputs

The third parties could also reward the group members for the individual inputs that they made. In particular, the third parties could consider whether the inputs were successful,
i.e. whether the answer was correct and led to an increase in the joint output, or incorrect and thus did not increase the output. For the symmetric cases in which both or none of the group members knew the right answer, we again predict that the third parties will distribute the joint output equally, because both of the subjects within the group created the distributable output in equal measure. For the asymmetric cases, however, we predict that the subject who knew the correct answer will receive a larger share $a$ of the joint output than the subject who was wrong (i.e. $a > 0.5$).\footnote{If the third parties reward the group members who give the wrong answer for at least participating in the experiment and for trying to answer the knowledge question, then we should observe that $a$ is below 100\% (i.e. $a < 1$). If the third parties decide according to this norm, then we predict that the share $a$ of the group member who answered correctly will be constant across our payoff matrices, i.e. independent of the marginal productivities realized by knowing the right answer.}

This distribution norm is closely related to the fairness ideal of accountability according to Konow (2000). The accountability principle recommends that the allocations depend only on (endogenous) factors that are completely under an individual’s control (e.g. the effort level, the effort intensity or the investment level chosen), whereas individual characteristics beyond an individual’s control (e.g. talent, ability or traits) are neglected. However, the marginal productivities are completely exogenous in our production task. We cannot control whether our subjects perceive the input in the form of answering only one question as effort and thus as endogenous, or as partially exogenous due to luck when the question is chosen or due to the subject’s inherent talent.\footnote{Thus we cannot differentiate between fairness based on individual inputs and the accountability principle.}

**Distribution based on the marginal productivities**

Alternatively, the third parties could take into account the individual marginal productivities, i.e. how the team members increased the joint output by giving the correct answer. Accounting for marginal productivities is in line with the fairness ideal of strict libertarianism (Nozick 1974).

In the sequential decision treatments, the marginal productivities are easy to attribute, irrespective of whether they are explicitly presented (TPTSQM) or not (TPTSQNM). In the simultaneous treatments TPT and TPT2R, the marginal productivities are also apparent if only one group member answers the question correctly (i.e. for the cells $A_rB_w$ and $A_wB_r$). For the additive matrices ($JP_3$, $JP_5$, $JP_7$), the marginal productivities are also clearly defined for the cell $A_rB_r$. For the non-additive matrices, in contrast, it is not clear which of the subjects had more ‘responsibility’ for creating the joint output in the cell $A_rB_r$ (i.e. who the first mover was).

A natural generalization of the marginal productivities to the simultaneous treatments is the Shapley value (Shapley 1953), which is the average marginal contribution of each subject in a randomized decision sequence. For the cell $A_rB_r$, the Shapley value is the average of the marginal productivities if A moves first and if B moves first. Because we focus on gains, the reference point is that none of the subjects knows the right answer, i.e. the subjects start from a joint output of 20 points.\footnote{We assume that if both subjects give the wrong answer, then 20 points will be distributed equally. Consider the payoff matrix}
for which the marginal productivities are additive. In the asymmetric case $A_wB_r$ (90 points), B’s marginal productivity is 70 points. Hence B should receive 70 points more than in the reference situation. Thus we predict an allocation of 10 points for A and 80 points for B. If, in contrast, A answers the knowledge question correctly and B is wrong (30 points), then A’s marginal productivity is 10 points. Hence we predict an allocation of 20 points for A and 10 points for B. In the additive matrices, however, the Shapley value for the case $A_wB_r$ does not depend on the sequence of decisions. For the matrix $JP_3$, for example, B’s Shapley value is 70 points, and A’s Shapley value is 10 points. For the symmetric cases $A_rB_r$ of the non-additive matrices, in contrast, B’s Shapley value, $S^\text{Gain}_B$, can be derived by dividing the sum of B’s marginal contributions when B decides as a first and as a second mover. An example in which the players’ marginal contributions are not identical for the two types of move is provided by the matrix $JP_2$.

Here, the Shapley values are $S^\text{Gain}_A (10 + 40)/2$ 25 points and $S^\text{Gain}_B (40 + 70)/2$ 55 points. The individual Shapley values (see Table 3) add up to 80 points for each of the output matrices, which is exactly the total contribution realized if both group members answer the question correctly (100 points) rather than incorrectly (20 points).

Table 4 shows the corresponding shares that B should receive if we assume that: (1) the payoff $A_wB_w = 20$ is split equally; (2) the individual marginal productivities are enforced in the asymmetric cases $A_wB_r$ and $A_rB_w$; (3) the shares of $\alpha_A (S^\text{Gain}_A + 10)/100$ and $\alpha_B (S^\text{Gain}_B + 10)/100$, respectively, are realized in the symmetric case $A_rB_r = 100$. Note that the share of the subject who answers correctly increases with the marginal productivity. We predict that the shares for B, $\alpha_B$, will increase with the output resulting from situation $A_wB_r$, and decrease with the output resulting from $A_rB_w$. The more A (B) contributes to the joint output by knowing the right answer, the lower (higher) the share for B will be. In particular, the shares should depend not on the fact that one of the subjects knew the right answer per se, but only on the increase in the distributable output realized by giving the right answer.

| Table 3: Shapley Values for Subjects A and B (in Points), by Joint Production Payoff Matrices |
|-----------------|-----------------|-----------------|-----------------|
|                 | $A_wB_r$         | $A_rB_r$         | $A_rB_w$         |
|                 | 30 points        | 60 points        | 90 points        |
| $A_wB_w$        | 40; 40           | 25; 55           | 10; 70           |
| $A_rB_w$        | 55; 25           | 40; 40           | 25; 55           |
| $A_rB_r$        | 70; 10           | 55; 25           | 40; 40           |
In this section, we first show how the third parties distribute the joint output if both group members do not know the answer. We consider the cell $A_wB_w = 20$ as the reference point. Then we discuss the asymmetric situations in which one group member knows the answer. In these situations, the marginal productivities are very intuitive. Finally, we consider the case in which both group members know the answer; here, we determine the marginal productivities by using the Shapley value. We present the results first for the simultaneous treatments and then for the sequential treatments.

Our results are based on two tables (Tables 5 and 6), in which we show the shares that the third parties assign to the group member $B$, conditional on subjects $A$’s and $B$’s contributions to the output. In Table 5, we aggregate on the treatment level. In Table 6, we separately show the results for the different situations and also report the predictions based on the marginal productivities. For the case in which both group members know the answer, we report the Shapley value, which is the appropriate measure for the shares that the subjects should get in treatments TPT, TPT2R and TPTSQNM with a simultaneous framing of the marginal contributions, as well as for treatment TPTSQM, in which the marginal productivities are presented sequentially. We conclude the section with regression analyses.

**Descriptive statistics**

The baseline case—both group members do not know the answer. We have the following result.
Result 1. In the symmetric case in which both subjects' inputs did not increase the joint output \((A_wB_w)\), the third parties divide the joint production payoff of 20 points equally.

Table 5 displays the shares that the third parties allocated to the subjects B in our four treatment conditions (averages across all nine payoff matrices). It illustrates that the third parties in TPT, TPT2R, TPTSQNM and TPTSQM allocated approximately 50% of the joint output of 20 points to subject B if the subjects A and B both answered the question incorrectly.

In Table 6, we separately show for each payoff matrix the average allocations that the third parties suggested for subjects B. For all nine payoff matrices, we made the six pairwise comparisons between the four treatments regarding the allocations to subjects B. For the symmetric case \((A_wB_w)\), a two-sided \(t\)-test (Wilcoxon signed-rank test) shows that only six (five) out of 54 situations are statistically significant at the 10% level. Moreover, two-sided \(t\)-tests show that the share distributed to subject B significantly differs from 0.5 in only one out of the 36 payoff matrices. We conclude that the equal distribution of the 20 points is chosen in all situations, irrespective of the treatment condition.

A regression analysis for each treatment in which we take data for the symmetric case \((A_wB_w)\) and regress the shares allocated to the subjects B on dummy variables for the nine different payoff matrices corroborates this result. We do not find evidence of significant differences across the payoff matrices within any of our four treatment conditions (only the allocation of \(A_wB_w\) in the matrix \(JP_2\) of TPT2R is significantly different). Unsurprisingly, the payoff matrix does not affect the allocation of the 20 points resulting from the fact that neither A nor B answered the question correctly.

The equal allocation of 20 points is in line with the predictions of distribution norms based on equal sharing and norms based on accounting for inputs. Moreover, the results are related to the fairness ideal based on accountability and are in line with strict egalitarianism. If people focus on gains, then the fairness norm of accounting for marginal contributions also predicts shares of 0.5 for all matrices.
### Table 6

**Summary Statistics for TPT, TPT2R, TPTSQNM and TPTSQM (Shares that the Third Parties Allocated to the Subjects B; Averages by Payoff Matrix; Two-sided $t$-Tests that Compare the Shares with 0.50)**

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**Notes**

The results of binomial tests confirm those of the $t$-tests discussed in the text.

*, **, *** indicate significant at the 10%, 5%, 1% level, respectively.
Asymmetric cases—only one group member knows the answer. We have the following result.

**Result 2.** In the asymmetric cases in which only one subject's input increased the joint output \((A_rB_w, A_wB_r)\), the third parties distribute more than half of the joint output to the subject who answered the question correctly. The allocations of the uninvolved third parties in TPT are more extreme than those of the involved third parties in TPT2R, TPTSQNM and TPTSQM.

Table 5 shows that in the asymmetric cases, the third parties distribute, on average, more than half of the joint output to the subject who knew the correct answer to the question. If only subject A was right, then the third parties in TPT, TPT2R, TPTSQNM and TPTSQM allocated, on average, 28.40%, 26.96%, 37.35% and 33.69%, respectively, of the joint output to the subjects B. For all of our treatments, the shares for B in the asymmetric cases \(A_rB_w\) are significantly lower than 50% \((t\text{-test, level of significance at } 1\%); \text{ also compare with Table 6 for } t\text{-tests per treatment and payoff matrix}). If, in contrast, only subject B was right, then the third parties in TPT, TPT2R, TPTSQNM and TPTSQM allocated, on average, 70.03%, 71.07%, 60.52% and 66.43%, respectively, to the subjects B. For all of our treatments, the shares for B in situation \(A_wB_r\) are larger than 50% and are, apart from one case, significant \((t\text{-test, level of significance at } 1\%); \text{ also compare with Table 6 for } t\text{-tests per treatment and payoff matrix}).

Figures 1 and 2 illustrate Result 2. Figure 1 depicts the frequencies of the shares distributed to subjects B if only subject A gave the correct answer (average over all nine matrices). In all of the treatments, most of the third parties allocated 50% or less of the

FIGURE 1. Frequencies (in %) of the shares that the third parties distributed to the subjects B if only subject A was right (average frequencies of all nine payoff matrices).
joint output to subject B. Figure 2 shows the average frequencies of the shares allocated to the subjects B if only subject B was right. It is evident that the third parties in this situation allocated at least half of the output to subject B in all of the treatments.

Overall, the results for the asymmetric cases are consistent with the fairness norm of accounting for individual inputs and thus closely related to the fairness ideal of accountability. However, we find that the distributions are somewhat heterogeneous across the treatments. In particular, when comparing the modal allocations, we observe that for the uninvolved third parties in TPT, the allocations are more extreme, i.e. the modal allocations are 0% and 100% compared to approximately 30% and 70% in TPT2R, TPTSQM and TPTSQNM. Being involved in the same production process, yet within another team, thus seems to shift the modal allocations towards more equal distributions.

**Distributing the joint success—both group members know the correct answer.** We have the following result.

**Result 3.** In the symmetric case in which both subjects’ inputs increased the joint output \((A, B)\), the third parties distribute the joint output of 100 points equally in the treatment conditions in which the individual marginal contributions were not presented in a salient manner (TPT, TPT2R and TPTSQNM).

Table 5 shows that in the symmetric case in which both subjects knew the correct answer, the subjects in the role of C, on average, allocated the resulting 100 points equally to A and B. If both subjects knew the correct answer, then the third parties in TPT, TPT2R and TPTSQNM distributed approximately 50%, 50% and 51% of the 100
points to subject B. Figure 3 illustrates the result that almost all of the third parties allocated half of the joint output to subject B.

However, the average might be misleading because it aggregates the different situations. If we consider the situations separately, and make a pairwise comparison between treatments TPT, TPT2R and TPTSQNM, we find that only three (one) out of the 27 comparisons are (is) statistically different at the 10% (5%) level (Wilcoxon rank sum tests). This result can also be confirmed using a regression analysis. Using data for the symmetric cases $A_rB_r$, a regression of the shares allocated to subjects B on dummy variables for the different payoff matrices shows that for TPT and TPT2R, the payoff matrix did not affect the distribution of the 100 points. These results show that in the symmetric situations $A_rB_r$, the third parties do not seem to consider the team members’ different individual productivities but rather share the joint output equally. As a result, for situation $A_rB_r$, our data for TPT, TPT2R and TPTSQNM are in line, not with the predictions for distribution norms considering marginal productivities and thus libertarian fairness ideals, but rather with equal sharing and with the distribution according to individual inputs.

Result 4. The marginal productivities play an important role for the distribution only if they are presented in a salient manner (TPTSQM), which is not the case for TPT, TPT2R and TPTSQNM.

Result 3 for the symmetric cases $A_rB_r$ states that the data from TPT, TPT2R and TPTSQNM are consistent with both equal sharing and accounting for inputs. Further, Result 2 for the asymmetric cases $A_rB_w$ and $A_wB_r$ indicates that a distribution norm

Figure 3. Frequencies (in %) of the shares that the third parties distributed to the subjects B if both subjects gave the right answer (average frequencies of all nine payoff matrices).
based on inputs is more appropriate to explain our data. For the treatments in which the marginal productivities were not presented saliently, we do not find evidence that the third parties took the marginal productivities into account when making their distributional choices.

If the third parties indeed choose a distribution according to the individual marginal productivities, then we should observe shares for subject B, $x_{B}$, in the following order for our payoff matrices: $x_{B}^{1,4,7} < x_{B}^{2,5,8} < x_{B}^{3,6,9}$ for the situation $A_{w}B_{r}$, and $x_{B}^{1,2,3} < x_{B}^{4,5,6} < x_{B}^{7,8,9}$ for the situation $A_{r}B_{w}$. In Table 7, we show the average shares for B, aggregated for these combinations of situations. The result shows that not all the data are in line with these predictions in treatments TPT, TPT2R and TPTSQNM. Only in treatment TPTSQM in which the marginal productivities were salient is there a treatment effect in the expected direction, though admittedly small. Nevertheless, if we use the $t$-test to compare the six situations that are predicted to result in a share different from 0.5, we find that all of the tests are significant at the 5% level.

In the symmetric cases $A_{r}B_{r}$ of the non-sequential treatments TPT and TPT2R, the marginal productivities do not predict the third parties’ allocations. As Table 6 shows, the same result is true for the sequential treatment TPTSQNM. The shares allocated to subject B do not even correlate with the predicted marginal gains in the sequential game. This result is different for treatment TPTSQM. Subject B gets the highest shares in the three situations in which B’s marginal contribution is 70 points, and is lowest in the three situations in which B’s marginal contribution is 10 points. These differences are also significant ($t$-tests with pairwise comparisons of the situations with different marginal contributions of B all $p < 0.05$). The values are significantly higher than 0.5 in situations 1, 2 and 3, and significantly lower than 0.5 in situations 7, 8 and 9 ($t$-test, $p < 0.05$). These findings indicate that an emphasis on marginal productivities shifts the distributional choices to accounting for marginal productivities (libertarian fairness ideal), but that the framing as a sequential production process alone does not. The marginal productivities thus affect the distributional choices only if they are readily apparent.

**Regression analysis**

In this subsection, we report the results of regression analyses conducted to confirm our results from the descriptive statistics and to determine the relative importance of the different distribution norms. Table 8 provides the results of separate regressions for each treatment, with the shares allocated to the subjects B as dependent variables and with subjects as clusters. To investigate whether the group members who had answered their question correctly received a larger share than those who were wrong (Result 2), we
include the explanatory variables $A_{right}$ and $B_{right}$ as dummy variables. $A_{right}$ ($B_{right}$) takes on the value 1 if subject A (subject B) knew the correct answer to the question, and the value 0 otherwise. To test whether the third parties distributed according to marginal productivities (Result 4), we include the variable $marginal\ productivity-0.5$. For treatment TPTSQM with sequential framing, we use the sequence ‘first A, then B’ to determine the variable $marginal\ productivity-0.5$. For the simultaneous treatments TPT, TPT2R and TPTSQNM, the variable $marginal\ productivity-0.5$ is the Shapley value less 0.5.\footnote{In line with Result 4, the individual marginal productivities as reflected in the Shapley values thus do not affect the distributional choices in the treatments in which we did not make the marginal productivities highly apparent, but considerably shaped the allocation when the realization of the marginal productivities was framed as a sequential process. The behavioural effect of the framing that we implemented in TPTSQM might result from a shift in the individual perceptions of distributive fairness, emphasizing the amount.

The regressions also confirm Results 1 and 3 for treatments TPT, TPT2R and TPTSQNM. The effect of the variable measuring the marginal productivities is small and non-significant, and taking the non-significant constants into account, the joint output is shared almost equally in all three treatments if both group members were equally responsible for its realization (Result 3) and if both group members were wrong (Result 1).

For our treatments with a simultaneous framing (TPT and TPT2R) as well as for treatment TPTSQNM with a sequential framing, the variable $marginal\ productivity-0.5$ is non-significant. In the regression for treatment TPTSQM, in contrast, the coefficient on $marginal\ productivity-0.5$ is highly significant. In line with Result 4, the individual marginal productivities as reflected in the Shapley values thus do not affect the distributional choices in the treatments in which we did not make the marginal productivities highly apparent, but considerably shaped the allocation when the realization of the marginal productivities was framed as a sequential process. The behavioural effect of the framing that we implemented in TPTSQM might result from a shift in the individual perceptions of distributive fairness, emphasizing the amount.
of additional points earned by knowing the correct answer rather than the input itself.

To confirm the existence of this shift in the fairness norm, we ran a separate regression for each subject, with the shares allocated to subject B as the dependent variable and \( \text{Shapley}_\text{Gain} \), \( A_{\text{right}} \) and \( B_{\text{right}} \) as explanatory variables. Based on the coefficients from these 102 regressions, we can cluster the third parties into three different types according to their distributive norms: Equal sharers have coefficients of approximately 0. Subjects accounting for marginal productivities are characterized by the lowest constants and the highest (positive) coefficients on \( \text{Shapley}_\text{Gain} - 0.5 \). In addition to rather high constants, the participants who allocated based on inputs have large (negative) coefficients on \( A_{\text{right}} \) and large (positive) coefficients on \( B_{\text{right}} \). For each treatment, Table 9 shows the percentage of subjects in the role of C that can be classified as one of these types. With 38.46%, TPTSQM is the treatment with the lowest percentage of subjects distributing points according to inputs. In addition, the percentage of subjects accounting for marginal productivities is higher in TPTSQM than in any other treatment (34.62%), in which the percentage ranged from 4.17% to 12.50%. Our results for the remaining treatments are qualitatively similar to those of Cappelen et al. (2007, 2010, 2013).

In summary, we find that distribution norms based on inputs can well explain our data for the treatments without an explicit emphasis on marginal productivities (i.e. for TPT, TPT2R and TPTSQNM). The marginal productivities in contrast do not seem to be relevant in these treatments. Because we showed our subjects all of the nine matrices, the marginal productivities were observable but not always readily apparent due to the differences in the additivity of the payoffs resulting from the individual inputs. In treatment TPTSQM, we implemented an economically equivalent situation, but we made the marginal productivities as apparent as possible by accentuating the sequential framing of the production process and the marginal productivities realized from knowing the correct answer to the knowledge quiz. This framing had significant behavioural effects. The prevalent distribution norm shifted to accounting for marginal contributions. A sequential framing without an emphasis on the marginal productivities, as implemented in TPTSQNM, was not sufficient to make marginal productivities salient.

### IV. Conclusion

This paper presents the results of an experimental study designed to investigate the relevance of different norms of distributive fairness in a joint production process in which
the marginal productivities are salient to a different degree. In our experiment, both subjects within a team had to answer a knowledge question to jointly generate an output. The joint production payoff was 20 points if both subjects gave the wrong answer and 100 points if both subjects answered the question correctly. The payoffs in the asymmetric cases in which only one subject was right varied across the nine payoff matrices that we used. We included matrices with synergies (i.e. the additional payoff increases of both team members were less than 80 points) and negative externalities (i.e. the sum of the marginal productivities exceeded 80 points). Our design allows us to investigate whether the subjects in the role of a third party (a) shared the joint production payoff equally among the team members (equal sharing), (b) rewarded the subjects who knew the correct answer (accounted for individual inputs), or (c) took into account the (exogenously given) individual marginal productivities.

Our results indicate that the distribution norm that applies to all four treatments is to acknowledge the individual inputs to the joint output. In particular, in the asymmetric cases, the third parties allocated more points to the subject who knew the correct answer to the knowledge question. In the symmetric cases in which both subjects either knew or did not know the correct answer, the third parties distributed equally. The predominance of this distribution norm is robust to whether the third parties were never producers themselves or a member of another production team. We found that the marginal productivities were not taken into account if they were not made very salient. The marginal productivities did not affect the third parties’ distributional choices in the treatments with a simultaneous framing and in a treatment with a sequential framing but without an emphasis on the marginal productivities. Only in the treatment with an emphasis on the marginal productivities (TPTSQM) did the third parties distribute according to the marginal productivities. Thus although all our framings are economically equivalent, the marginal productivities were considered only if they were made apparent.

Our results offer some important insights into the design of performance schemes in cases where the marginal productivities are not readily observable because the individual inputs to the joint production are not necessarily additive. For these situations, the normatively appealing and frequently implemented equal sharing norm appears to be fair only if both team members’ inputs are symmetric in the sense that both do or do not increase the output. If the inputs are asymmetric—e.g. one manager’s marketing strategy leads to an increase in the sales of a product whereas the other manager’s effort does not—then equal sharing does not seem to be a distribution rule that is regarded as fair. In this case, the manager who has contributed should receive a share above 50%. This distribution norm is closely related to the fairness ideal of accountability (Konow 2000). Moreover, our results indicate that marginal productivities should be integrated into performance measures only if they are really salient, e.g. if they are explicitly presenting in the performance reports.

Our experimental design is not without limitations. First, the inputs were in the form of answering one multiple-choice knowledge question, and the marginal productivities were exogenously given. Thus the personal productivities were not observable, and we cannot differentiate between effort, talent and luck as, for example, Luhan et al. (2013) do. Moreover, future experiments could employ a design that controls for talent and/or intention, for example, by letting subjects determine the level of difficulty of the questions that they have to answer. Second, the relative importance of the distribution norms that we investigate might be different in situations in which people lose rather than gain
money. Thus our findings might not extend to decisions on tax payments or donations to third world countries. Further research thus could address the prevalence of different fairness norms in situations in which people spent part of their wealth.

APPENDIX: EXAMPLE TPTSQM

As an example for the sequential framing in TPTSQM, consider the joint production payoff matrix

\[
JP_8 = \begin{pmatrix}
20 & 60 \\
90 & 100
\end{pmatrix}.
\]

We started with 20 points and informed our subjects on their computer screens that the joint production payoff would not increase further if A and B both gave the wrong answer. In the next line on the screen, we explicitly informed the subjects that the output would increase by 40 points if B (but not A) knew the correct answer. The following line stated that the joint output, starting from the baseline of 20 points, would increase by 70 points if A (but not B) answered the question correctly. The last line told the participants that the output would go up by 70 points if A was right and by additional 10 points if B was also right. Thus the framing in TPTSQM implied that A was the first mover in creating the joint production payoff of 100 points. In TPTSQNM, we implemented the same sequential framing with A as the first mover. In contrast to TPTSQM, however, we informed the subjects about the joint output that could be realized if neither A nor B / only B / only A / both A and B answered the question correctly.

APPENDIX: FOCUS ON LOSSES

Predictions for a distribution based on the marginal productivities

If subjects focus on losses instead of on gains, then the reference point is the case in which both subjects know the right answer; again, we assume that the subjects will share the resulting 100 points equally in this case. For the payoff matrix

\[
JP_3 = \begin{pmatrix}
20 & 90 \\
30 & 100
\end{pmatrix}.
\]

A (B) squanders 10 points (70 points) by not knowing the correct answer. Thus these losses should be subtracted from the 50 points that A and B would receive in the reference situation. Therefore we predict \(A\_wB\_r\) (90 points) to be allocated at 40 points for A and 50 points for B. For the case \(A\_wB\_w\) (30 points), A should receive 30 points and B 0 points, because the experimental design precludes negative shares. For the symmetric case \(A\_wB\_w\) (20 points), we account for the sequential form of destroying points by not knowing the right answer by again deriving Shapley values. Because the Shapley values listed in Table 3 do not depend on the reference point, A (B) should receive a share of \(\alpha_A = \min[(50 - S^{loss}_A)/20; 1] = 1\) (\(\alpha_B = \max[0; (50 - S^{loss}_B)/20] = 0\)) in the situation \(A\_wB\_w\). Table A1 shows the predictions regarding the shares for B if subjects adhere to libertarian fairness and focus on losses. In the table, we can see that the shares for B should increase (decrease) with the output resulting from \(A\_wB\_w\) (\(A\_wB\_r\)), i.e. the larger the amount of the joint production payoff that A (B) destroys by not knowing the right answer, the higher (lower) B’s share will be. Again, the shares should depend only on the marginal losses realized by not knowing the correct answer.

Let us consider the symmetric case in which both subjects’ inputs did not increase the joint output (\(A\_wB\_w\)). If the subjects focus on losses, taking marginal productivities into account predicts shares of 0.5 only for the matrices \(JP_1, JP_5\) and \(JP_9\). For the other cases, one player should get the
### Table A1

**Predictions Regarding the Shares Distributed to the Subjects B (Fairness Based on Marginal Productivities With a Focus on Losses)**

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<td>w</td>
<td>1.0</td>
<td>1.0</td>
<td>w</td>
</tr>
<tr>
<td>r</td>
<td>0.17</td>
<td>0.50</td>
<td>r</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject A</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>w</td>
<td>r</td>
<td>w</td>
</tr>
<tr>
<td>w</td>
<td>1.0</td>
<td>1.0</td>
<td>w</td>
</tr>
<tr>
<td>r</td>
<td>0.44</td>
<td>0.50</td>
<td>r</td>
</tr>
</tbody>
</table>

### Table A2

**Regressions with the Shares Offered to the Subjects B (Minus 0.5) as the Dependent Variable**

<table>
<thead>
<tr>
<th></th>
<th>TPT</th>
<th>TPT2R</th>
<th>TPTSQM</th>
<th>TPTSQNM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapley_Gain-0.5</td>
<td>-0.0133</td>
<td>-0.0396</td>
<td>0.201***</td>
<td>-0.0319</td>
</tr>
<tr>
<td></td>
<td>(0.0779)</td>
<td>(0.0383)</td>
<td>(0.0609)</td>
<td>(0.0586)</td>
</tr>
<tr>
<td>Shapley_Loss-0.5</td>
<td>0.0548**</td>
<td>-0.0324*</td>
<td>-0.00475</td>
<td>-0.0343</td>
</tr>
<tr>
<td></td>
<td>(0.0223)</td>
<td>(0.0163)</td>
<td>(0.00941)</td>
<td>(0.0211)</td>
</tr>
<tr>
<td>A_{right}</td>
<td>-0.197***</td>
<td>-0.242***</td>
<td>-0.100***</td>
<td>-0.136***</td>
</tr>
<tr>
<td></td>
<td>(0.0447)</td>
<td>(0.0399)</td>
<td>(0.0208)</td>
<td>(0.0231)</td>
</tr>
<tr>
<td>B_{right}</td>
<td>0.194***</td>
<td>0.242***</td>
<td>0.111***</td>
<td>0.135***</td>
</tr>
<tr>
<td></td>
<td>(0.0475)</td>
<td>(0.0367)</td>
<td>(0.02)</td>
<td>(0.0238)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.00166</td>
<td>-0.00428</td>
<td>-0.00451**</td>
<td>-0.0024</td>
</tr>
<tr>
<td></td>
<td>(0.00437)</td>
<td>(0.0073)</td>
<td>(0.00216)</td>
<td>(0.00526)</td>
</tr>
</tbody>
</table>

| Observations   | 864 | 864 | 936 | 1008 |
| R-squared      | 0.392 | 0.443 | 0.499 | 0.25 |
| Number of clusters | 24 | 24 | 26 | 28 |

**Notes**

Robust standard errors in parentheses.

*, **, *** indicate significant at the 10%, 5%, 1% level, respectively.
whole pie. This prediction strongly contrasts the results that show an approximately equal distribution in all these situations.

In the situation $A_wB_v$, the theory with focus on losses predicts the ordering $x^B_{1,4,7} > x^B_{2,5,8} > x^B_{3,6,9}$ of shares allocated to subject B, and in the situation $A_vB_w$, it predicts the ordering $x^B_{1,2,3} < x^B_{2,5,6} < x^B_{3,7,8,9}$ of shares allocated to subject B. In the experiment, we observe average allocations across the respective three matrices of 0.72 > 0.69 = 0.69 (TPT) and 0.73 > 0.68 < 0.71 (TPT2R) for $A_wB_v$, and of 0.26 < 0.29 < 0.30 (TPT) and 0.28 < 0.29 > 0.24 (TPT2R) for $A_vB_w$. Thus the theory according to a focus on losses does not make good predictions; even the qualitative predictions are wrong.

**Regressions**

To test the predictive power of marginal productivities based in losses, we use a regression in which we include the variables $Shapley_{Gain-0.5}$ and $Shapley_{Loss-0.5}$, the shares predicted for subjects B with a focus on gains and on losses, minus 0.5; see Table A2. For our conditions without an emphasis on marginal productivities (TPT and TPT2R), the variable $Shapley_{Gain-0.5}$ again is not significant; $Shapley_{Loss-0.5}$ is significant at the 5% level only in treatment TPT, and borderline significant in treatment TPT2R.

**NOTES**

1. Karagozolu (2012) shows that the prevalence of different fairness norms depends on the type of input made. The findings from the experiments using monetary investments indicate that the majority of subjects prefer equal shares (see, for example, Gantner et al. 2001; Cappelen et al. 2007). For real-effort tasks, such as folding letters or typing in documents, the evidence is less supportive of equal sharing and indicates an increased acknowledgment of the individual inputs (see, for example, Konow 2000; Cappelen et al. 2010, 2013).

2. A typical example is a piece-rate compensation scheme, e.g. a payment per unit of installed car windows (Lazear 2000), a payment per planted tree (Paarsch and Shearer, 1999), or a payment per unit of harvested fruit (Bandiera et al. 2007).

3. Ashlagi et al. (2012) even show that in the cases in which it is impossible or hard to verify the legitimacy of the individual claims of an outcome, Nash bargaining escalates to the highest possible level, and equal sharing is also a result of a non-cooperative game.


5. There is evidence indicating that the subjects are prone to a self-serving bias if they are equipped with more bargaining power (see, for example, Babcock et al. 1995; Babcock and Loewenstein 1997; Charness and Haruvy 2000; Konow 2000, 2009; Gächter and Riedl 2005; Luhan et al. 2013; for an overview, see Konow 2003). Luhan et al. (2013) demonstrate that the bargaining claims not only depend on the relative performance, but also substantially deviate from the fairness ideals elicited ex ante.

6. Note that in the studies cited in the text, the individual absolute contributions or relative productivities are endogenously determined by the subjects answering several questions.

7. Gächter and Riedl (2006) also study impartial arbitrators. However, they use a vignette study design.

8. During the production task, all of the participants saw six multiple-choice questions from a knowledge quiz to determine which of these questions would be relevant for the first matrix. Ensuring that the questions would not be repeated if the same number came up twice, the same procedure was carried out for the second matrix.

9. In an earlier version of this paper, we also reported the data from ultimatum game versions of some of our treatments. The main results are in line with the insights from the dictator games reported here. The data are available from the authors on request.


11. Strict accountability implies that if only one of the subjects knows the answer, then this subject would deserve the total output. We restrict our analysis to a qualitative prediction because we expect people with pure fairness ideals to be rare.

12. See, for example, Luhan et al. (2013) for a systematic analysis of talent, effort, and luck.

13. One could also focus on losses and assume that subjects giving wrong answers are responsible for destroying the joint output of 100. We determined the corresponding Shapley values and report the results in
Appendix: Focus on losses. We do not include the analysis in this paper because the notion is not only less intuitive, but also performs poorly in the econometric estimates.

14. Interestingly, there is not a big difference between using the sequential and simultaneous variants of the Shapley value for all treatments.

15. To have comparable results, we use the simultaneous version of the Shapley value for all treatments.

REFERENCES


(2003). Which is the fairest one of all? A positive analysis of justice theories *Journal of Economic Literature*, 41(4), 1188 239.


