Universität Bielefeld/IMW

Working Papers
Institute of Mathematical Economics

Arbeiten aus dem
Institut für Mathematische Wirtschaftsforschung

Nr. 46

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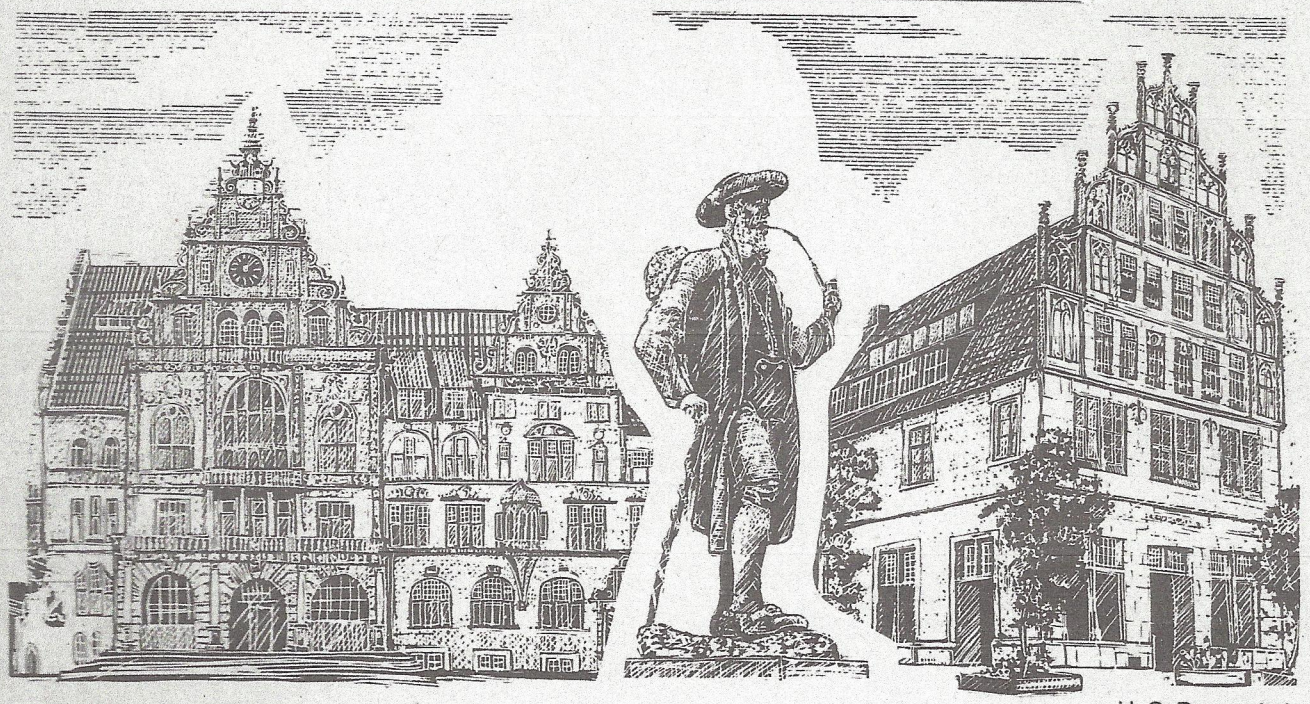
July 1976



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The equity principle in economic behavior

by Reinhard Selten

It is the aim of this paper to throw some light on the way in which a simple equity principle of reward allocation influences observed economic behavior. Experimental results strongly suggest the relevance of the principle for the resolution of economic distribution conflicts.

The basis of the theoretical explanation proposed here is Homans's theory of distributive justice, even if his terminology will not be employed [Homans 1961][1)].

From the normative point of view of modern utilitarian ethical theory, as it appears in the work of J.C. Harsanyi [Harsanyi 1955], the equity principle may not be justifiable as an adequate tool of collective decision making. Nevertheless, the fact that certain normative rules are often applied in practice, should not be neglected by the theorist. Discrepancies between normative results of Bayesian decision theory and empirically observed human behavior must be expected in the light of the theory of bounded rationality [Simon 1959], [Sauermann-Selten 1962]. The equity principle looks very reasonable as a normative rule which can be applied by decision makers without extraordinary capabilities of logical analysis and computation.

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1) In economic contexts it is advisable to avoid the use of the word "investment" in the sense of Homans.

Dividing a dollar: Let us first look at a very simple experimental situation: Two experimental subjects are asked to divide a dollar among themselves. This experiment has actually been performed by **Nydegger and Owen** /Nydegger-Owen 1974/. Invariably the subjects agreed to split evenly. Each of them received 50 c.

There are at least three different explanations for this kind of behavior:

(A) The agreement is based on a normative equity principle.

(B) The agreement reflects the symmetry of the power situation.

(C) The agreement is at the only prominent point in the sense of Schelling /Schelling 1960/ .

Owen and Nydegger did not consider the ethical explanation (A) and the prominence explanation (C). It was their intention to test game theoretical solution concepts applicable to the situation.

Dividing 120 poker chips: In another experiment performed by **Nydegger and Owen** /Nydegger-Owen 1974/ two subjects A and B are asked to divide 120 poker chips among themselves; A receives a payoff of 2 c per poker chip and B receives a payoff of 1 c per poker chip. Invariably the result was that the subjects agreed on 40 chips for A and 80 poker chips for B. Thus they achieved an equal division where each of them received 80 c.

According to the Nash solution of the bargaining problem /Nash 1950/ favored by most game theorists, both A and B should receive 60 poker chips which corresponds to a payoff of 120 c for A and of 60 c for B.

Obviously the ethical explanation (A) and the power explanation (B) are possible here, too. The applicability of the prominence explanation (C) is dubious since the Nash solution, where both receive the same number of poker chips, does not seem to be less prominent than the equal dicision with a payoff of 80 c for both bargainers. One may of course say that the equal devision is more prominent because of its normative significance. This version of explanation (C) is hard to distinguish from explanation (A).

As we shall see in the light of other experiments it is not advisable to follow the natural inclination of a game theorist to concentrate his attention on power explanations.

Reward allocation experiments: An interesting line of experimental research on individual reward allocation has been initiated by Leventhal and his coworkers [Leventhal-Michaels 1969] and has been further pursued by Mikula and his associates [Mikula 1973, Mikula-Uray 1973, Mikula 1975] [2]. In a typical reward allocation experiment two subjects perform a common task in separate rooms; afterwards one of the subjects is asked to distribute a sum of money between both of them. He can divide the sum of money in any way he wants; he is free to take everything for himself.

In actual fact an experimental subject is rarely observed to exploit his power in this situation. An equal division of the

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2) Additional references can be found in the last mentioned paper by Mikula.

reward is a frequent outcome.

In most of Mikula's experiments the subject was led to believe that he had contributed more (e.g. 60%) or less (e.g. 40%) to the common goal. In the latter case, where the subject's own contribution appeard to be inferior, a tendency towards a reward distribution in proportion to the announced contributions was observed whereas in the former case, where the subject's own contribution appeared to be superior, the outcome was more in the direction of an equal division of the total sum.

Obviously the experimental reward allocation decisions were strongly motivated by considerations of social justice. The availability of a measure of achievement enables the reward allocator to apply a proportional equity rule. The proportional equity rule can be thought of as a modification of the equal division principle. Whereas the equal division principle prescribes the same reward for every person, the proportional equity rule prescribes the same reward for every unit of achievement.

The reward allocating subject in Mikula's experiments seems to choose between two conflicting norms: the simple equal division principle and the proportional equity rule. It is important to note that he tends to solve this conflict in his own disfavor. Mikula attributes this to a general norm of modesty which regulates social interactions between persons of different status. Status differences are expected to be acknowledged by the inferior partner and to be deemphasized by the superior partner /Mikula 1975/.

It must be pointed out that the monetary payoffs in the reward allocation experiments reported in the literature were moderate. One may ask the question whether a different kind of behavior would be observed if the same experiments were performed with high money payoffs. One may conjecture that the influcence of social norms is diminuished in the face of substantial monetary incentives.

As we have seen, power explanations do not contribute anything to the understanding of observed behavior in reward allocation experiments. This suggests that equal payoff divisions in game experiments with moderate money payoffs are due to the fact that the subjects' behavior is guided by equity norms rather than power considerations.

Friedman's duopoly experiments: In Friedman's duopoly experiments subjects who played the same asymmetric duopoly over many periods were permitted to exchange written messages. Generally the subjects succeeded to reach cooperation of a Pareto-optimal combination [Friedman 1967 and 1970]. Frequently this combination is at the "equal split point" where both profits are approximately equal. In other cases the agreement is between the equal split point and the joint profit maximum. Clearly the influence of the equal division principle can be seen here, too, even if this principle is modified by a tendency towards joint profit maximization. An interpretation in terms of a compromise between two different social norms suggests itself.

Some further evidence from duopoly experiments: In the duopoly experiments with continuous time and face to face bargaining

performed by C.C. Berg and the author the subjects usually succeeded to cooperate in spite of the fact that agreements were not enforcible. /Selten-Berg 1970/. Two distinctly different modes of cooperation were observed: (a) agreements with side payments providing for equal money payoffs for both players at the end of the game and (b) agreements without side payments at Pareto-optimal points with approximately equal profits for both players. These two modes of cooperation explain 15 of 18 cases where cooperation took place.

Both modes of cooperation employ the same principle of equal division but the measure of reward to which it is applied is different in both cases since money payoffs included initial assets which were not included in profits.

Power differences did not seem to have a visible influence on the way in which payoffs were distributed as a result of agreements. Our interpretation of the results was partly in terms of the prominence of the equal division and partly in terms of the stronger player's willingness to sacrifice his advantage for a chance to reach cooperation quickly. A revision of this interpretation seems to be indicated in the light of the research on reward allocation. These results suggest that the influence of the principle of equal division is due to its character as a social norm of distributive justice.

A general equity principle: The principle of equal division in its various modes of application and the proportional equity

rule can be understood as special cases of a more general equity principle, applicable to a wide range of situations which require the allocation of rewards to the members of a group. Suppose that the group has n members, numbered from 1,...,n. In order to be able to apply an equity rule similar to those discussed above it is necessary that there is an accepted way to measure rewards; we shall refer to this way of measurement as standard of distribution . For every possible reward allocation the standard of distribution defines a measure of reward r_i for every group menber i; where r_i is a non-negative real number.

If the situation requires nothing else than the distribution of a sum of money it is natural to apply a standard of distribution which takes the money payoffs to the group members as the measures of reward r_i. In order to illustrate the possibility of other standards of distribution one may think of cartel bargaining about supply quotas where these quotas can be taken as measures of reward. The case of the two modes of cooperation in the duopoly experiments performed by C.C. Berg and the author shows that sometimes several different standards of distribution may be applicable to the same problem.

A second requirement for the application of the more general equity principle is the availability of an accepted way to define an equitable reward combination $(r_1,...,r_n)$. This is done with help of a standard of comparison which assigns a positive weight w_i to each group member i. In many cases it is natural to apply an egalitarian standard of comparison with $w_i = 1$ for $i = 1,...,n$, but other standards of comparison are clearly possible. In the case of

the reward allocation experiments discussed above the announced measures of contribution to the common goal supplied an alternative **standard of comparison.**

An equitable reward combination can now be defined as a combination $(r_1,\ldots,r_n)$ which satisfies the following condition:

$$\frac{r_1}{w_1} = \frac{r_2}{w_2} = \cdots = \frac{r_n}{w_n}$$

An equitable reward combination may be described as a combination which allocates the same number of reward units to every weight unit. It is clear that the definition of an equitable reward combination crucially depends on the standard of distribution and on the standard of comparison which is applied to the situation.

Equitable cost distributions: The general equity principle can also be applied to problems involving the distribution of costs rather than rewards. Thus for example the costs of producing a public good may be distributed among its users according to a suitable standard of comparison. The formal structure of the equity principle remains the same in these cases, in spite of the fact that here a burden and not a benefit is distributed among the members of a group.

Properties of standards of distribution and comparison: The standards of distribution and comparison are not always uniquely determined by the character of the situation. On the other hand, they are by no means completely arbitrary. Generally the nature of the

problem suggests a finite number of alternative possibilities, among which the group members have to agree.

An obvious requirement which must be satisfied by reasonable standards of distribution and comparison is relevance to the problem. A standard of distribution must be a meaningful measure of the rewards or burdens to be distributed and a standard of comparison must be justifiable as substantially connected to the problem. Admittedly, this criterion of relevance is rather vague and needs interpretation in every special case. Nevertheless, it has an important influence on the selection of standards.

A second property which standards of distribution and comparison need in order to be able to serve their function as a basis for the computation of equitable distributions, may be called "accessibility": The numbers r_i and w_i must be easily observable without any ambiguity by all members of the group. Hidden variables like individual utilities are not accessible and therefore not feasible as standards of distribution or comparison. Social norms must be socially controllable. Therefore accessibility is a very important property of the standards of distribution and comparison.

Quota cartels: The literature on cartel formation illustrates the application of the equity principle in an economic context [Kastl 1963]. In quota cartels the supply quotas are a natural standard of distribution. Some average of past supplies is often taken as standard of comparison. Capacities may serve the same

purpose if the technology is such that an unambiguous method of measurement is easily available.

Equity and power: It is hard to believe that the influence of the equity principle on the resolution of economic distribution conflicts like that of the quota cartel should be entirely due to a desire to conform to social norms. It is plausible to expect that a powerful group member tries to get more than his share. Nevertheless there may be compelling reasons why a powerful individual may find it more profitable not to press his advantage. Suppose for example that two partners A and B must agree on the division of 100 money units and that on the one hand no other standard of comparison than the egalitarian one is applicable and on the other hand partner A is in some sense obviously more powerful and therefore has a very good reason to ask for more than 50. But how much more should he demand? In most cases it will not be easy to justify any number between 50 and 100 as a natural share of A. Hard bargaining may be required before any agreement is reached if A insists on any such share, say 70. On the other hand B knows that A is more powerful; therefore B accepts the principle that A should get at least 50. If A proposes the even split, B will immediately accept. In this way A can save himself a lot of trouble; moreover he shows his magnanimity and establishes a favorable spirit of cooperation.

Partner B has the same interest as A to reach an agreement quickly, but unlike A he does not have a natural lower limit

to his share other than 0. He cannot make a reasonable demand which is undisputably smaller than his power adequate share. Therfore only A has the possibility to act maguanimously in a secure way.

The concept of power: In the remarks on equity and power which have been made above the concept of power has been used in a naive sense which can be clarified by the following loose definition: power is the capability to secure more than one's equitable share. - Those who are able to do this are powerful whereas those who cannot even secure their equitable shares suffer from a power deficit.

In comparison to J.C.Harsanyi's thorough discussion of the dimensions of power this explanation is a rather cude one which cannot claim to exhaust the problem [Harsanyi 1962]. Nevertheless an important aspect of the everyday use of the word seems to be captured by relating power to equity.

Equity and coalition formation: It has been shown elsewhere that the results of characteristic function game experiments with face to face coalition bargaining agree surprisingly well with a rather simple theory called equal share analysis [Selten 1972]. Three hypotheses characterize a regular payoff configuration in the sense of this theory. The first hypothesis, exhaustiveness, requires that no union of coalitions which have been formed could have secured a greater collective payoff. The second hypothesis is satisfied if the payoff configuration is in the equal division core; this is

the case if no alternative coalition could have been formed by giving each of its members the same amount and more than he received in the end. The third hypothesis requires that within a coalition which has been formed a stronger player does not receive a smaller payoff than a weaker player. (The exact definition of "stronger" and "weaker" will not be repeated here. In most experimental cases the order of strength is intuitively clear.)

It has been shown that the set of regular payoff configuration is always non-empty [Selten 1972].

In order to illustrate the concept let us look at the following 3-person game v in characteristic function form:

$$v(i) = 0 \qquad \text{for } i = 1,2,3$$

$$v(1,2) = 100 \qquad v(1,3) = 90 \qquad v(2,3) = 80$$

$$v(1,2,3) = 120$$

Exhaustiveness requires that the three-person coalition forms and distributes 120 among its members. Player 1 is stronger than players 2 and 3 and player 2 is stronger than player 3. The third hypothesis asserts that the players agree on a payoff vector (x_1,x_2,x_3) which reflects the order of strength; we must have

$$x_1 \geq x_2 \geq x_3$$

At least one of the players 1 and 2 must receive at least 50; otherwise the payoff configuration could not be in the equal division core, since (1,2) could form and divide the payoff of

100 evenly and both 1 and 2 would receive more than in (x_1,x_2,x_3). In view of the conditions imposed by the order of strength it follows that player 1's payoff x_1 is at least 50. Similarily it can be seen that (x_1,x_2,x_3) cannot be in the equal division core unless at least one of the players 2 and 3 receives at least 40. It follows by $x_2 \geq x_3$ that we must have $x_2 \geq 40$. The payoff vectors belonging to the regular configurations for v are characterized by the following conditions:

$$x_1 \geq 50 \quad x_2 \geq 40$$
$$x_1 \geq x_2 \geq x_3 \geq 0$$
$$x_1 + x_2 + x_3 = 120$$

Obviously the egalitarian payoff vector $x_1=x_2=x_3 = 40$ is excluded by these conditions. Among the payoff vectors belonging to regular configurations, the vector (50,40,30) may be thought of as least different from the equitable distribution with the egalitarian standard of comparison.

As we have seen equal share analysis does not simply predict equal payoff divisions, but nevertheless the equity principle plays an important role in the determination of the set of regular payoff configurations. Whereas the payoff vectors in the ordinary core are stable against alternative coalition possibilities with arbitrary payoff divisions, the equal division core requires a weaker stability property. Only those distributions of coalition payoffs are considered to be potentially destabilizing which correspond to the principle of equal division. Such coalition agreements are especially

dangerous alternatives since the equity norm makes it easier to accept them. The weaker partners know that they cannot expect more than an equal share and the stronger partners do not have to justify their demands if they propose an equal division.

The strength of a player is perceived as related to his power in the sense which has been discussed above. Therefore it appears to be unreasonable to form a coalition where a weaker partner receives a higher share of the payoff than a stronger partner. This is quite clear if power is seen as related to equity.

Generalization of the equal division core: The experimental situations which gave rise to the development of equal share analysis are such that no other standard of comparison than the egalitarian one suggests itself. In practical economic conflict situation,which can be modelled as characteristic function games, other standards of comparison may be more natural. If the players are firms and the coalitions have the meaning of mergers,the value of a firm's total assets may be a suitable standard of comparison. Obviously for any given standard of comparison we can introduce a corresponding modification of the equal division core which may be called the equity core: Let $w_1,\ldots,w_n$ be the weights of the players according to the standard of comparions; the equity core of an n-person characteristic function game v is the set of all payoff configurations whose payoff vectors $(x_1,\ldots,x_n)$ have the property that there is no

non-empty coalition C with

$$\frac{w_i}{\sum_{i\varepsilon C} w_i} \, v(C) > x_i \quad \text{for every } i\varepsilon C.$$

The left side of this inequality shows the equitable share of player i in coalition C. As in the case of the equal division core the standard of distribution is given by the payoff x_i. If the characteristic function v is such that $v(i) = 0$ does not hold for every player i, one may wish to consider another standard of distribution, namely $x_i - v(i)$. In this way we receive the normed equity core characterized by the condition that for no non-empty coalition C we have

$$\frac{w_i}{\sum_{i\varepsilon C} w_i} \left[v(C) - \sum_{i\varepsilon C} v(i)\right] > x_i - v(i)$$

This is the obvious generalization of the normed equal division core which has been defined elsewhere [Selten 1972].

Non-equitable distribution conflicts: Undoubtedly there are some important economic distribution conflicts to which the equity principle cannot be applied, since it is impossible to find reasonable standards of distribution and comparison. Collective wage bargaining seems to be a case of this kind. Such distribution conflicts may be called non-equitable.

A fruitful experimental approach to wage bargaining has been provided by the macroeconomic decision game KRESKO [Tietz 1973]. R. Tietz and H.-J. Weber have developed several ingenious theoretical explanations of the KRESKO-data [Tietz-Weber 1972, Tietz 1975, Weber-Tietz 1975]. This research suggests that in non-equitable two-person bargaining situations the outcome is determined by a principle of balanced aspiration levels whose spirit is not dissimilar to that of the equity principle. The theoretical explanations by R. Tietz and H.-J. Weber do not only concern the final outcome but the whole bargaining process. A detailed discussion of this work will not be given here. We shall restrict our attention on the final outcome in order to exhibit the connections between the principle of balanced aspiration levels and the equity principle.

The principle of balanced aspiration levels: The principle is based on the idea that before the beginning of a bargaining session both partners form various aspiration levels and expectations about the outcome of the negotiations. Thus they form an estimate of what they can minimally secure, of what they can normally expect etc. In the KRESKO game the bargainers have to fill in questionnaires where they have to answer questions about five such levels. The levels can be arranged on an ordinal scale where ranks increase with increasing desirability and decreasing attainability. We shall refer to this scale as the aspiration scale.

An agreement satisfies the principle of balanced aspiration levels if the outcome is equally high on the aspiration scale

for both bargainers.

In spite of the fact that the subjects in the KRESKO-game are not informed about the opponent's levels on the aspiration scale, they succeed to attain approximately balanced aspiration levels at the final outcome. A feeling for the missing information seems to be developed as a result of the exchange of arguments during the verbal communication in the bargaining process.

The principle of balanced aspiration levels is not dissimilar to the equity principle discussed above. In both cases one can identify success related measures which are equalized. In this sense we may say that the idea of equity is inherent in the principle of balanced aspiration levels, too. On the other hand, the common scale of measurement which makes the aspirations and expectations of both bargainers comparable does not have the property of accessibility which is a crucial characteristic of the standards of distribution and comparison.

Equity and the formation of aspiration levels: Tietz and Weber did not explain the formation of aspiration levels. In this respect up to now only qualitative results could be derived from the KRESKO-data [Weber 1976]. In the case of equitable distribution conflicts, where standards of distribution and comparison are available, it is plausible to conjecture that the formation of aspiration levels will already be guided by the equity principle. Suppose for example that the group members perceive each other as equally

powerful. Then nobody has a good reason to demand more than his equitable share. In experimental situations of this type the equitable share is a natural focus point for the formation of aspiration levels. Therefore one can expect that at the equitable distribution the aspiration levels of all group members will be equal on the aspiration scale. If this is the case the equity principle coincides with the principle of balanced aspiration levels.

Experimental characteristic function games provide examples for distribution conflicts between partners of unequal power. Here we cannot expect the same coincidence of both principles as in situations without obvious power differences. A stronger player may aim at a higher payoff share than a weaker player. Considerations of equity can still have an indirect influence on the formation of aspiration levels. Equal shares of alternative coalition payoffs may serve as natural focus points. This is in agreement with the spirit of equal share analysis.

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