

# **Game Theory: The Language of Social Science ? \***

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## **Abstract**

The present paper tries in a largely non-technical way to discuss the aim, the basic notions and methods as well as the limits of game theory under the aspect of providing a general modelling method or language for social sciences.

\* dedicated to Professor Leonid Hurwicz in admiration

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# 1 Introduction

The First World Congress of the Game Theory Society took place from July 24 to 28, 2000 in Bilbao, Spain. Besides all living outstanding game theorists about seven hundred people attended that conference. Their fields of research belonged to several classical disciplines from Mathematics, Economics and Management and Decision Science, over Sociology, Psychology, Law and Political Science to Biology, Engineering, Computer and Neuro Sciences. This development had in some sense been predicted by Hurwicz (1945) who when discussing von Neumann and Morgenstern's (1944) book already wrote:

*The techniques applied by the authors in tackling economic problems are of sufficient generality to be valid in political science, sociology ...*

The Second World Congress in Marseille in 2004 that is just around the corner will most likely attract even more scientists from even more fields.

According to Robert Aumann and Sergiu Hart (Aumann and Hart, 1992)

*Game Theory may be viewed as a sort of umbrella or 'unified field' theory for the rational side of social science ... [that] does not use different, ad hoc constructs ... [but] develops methodologies that apply in principle to all interactive situations.*

One might see this description as an euphemistic overstatement of game theorists regarding their own discipline. But their view and emphasis on the crucial role of game theory is confirmed by the philosopher John Elster (Elster, 1982) who writes:

*... if one accepts that interaction is the essence of social life, then game theory provides solid micro foundations for the study of social structure and social change.*

Admittedly, there are other, more sceptical voices, too. So we find on the back cover of the book "Game Theory. A critical Introduction" by Hargreaves Heap and Varoufakis (1995) the provocative question:

*Does game theory simply repeat what everyone already knows in a language that no one understands?*

This formulation perfectly reflects a widespread hostility towards mathematics as a language and maliciously identifies “know” with “suspect”. The language of mathematics provides us with a level of precision and rigor of communication that can hardly be achieved otherwise and enables us to make the crucial progress from conjecture to proof and from suspicion to knowledge.

In Hurwicz (1953) we find the passage

*The theory of games thus has an undispatched fascination for, and a stimulating effect on, workers in many fields, ranging from (comparatively) pure mathematics to applied social sciences.*

Fifty years later game theoretic models have indeed already conquered large parts of social science and play an increasingly important role in other sciences. *But what exactly is game theory? What are its natural objectives? And where are the borders of game theory and the limits of game theoretic modelling?*

Game theory is a mathematical approach to the modelling of human interaction in groups and societies. Despite some much earlier work concerning various aspects and even notions of game theory, for instance by Edgeworth (1871), Cournot (1838), Zermelo (1912) or E. Borel (1921), it is almost generally agreed that, fathered by John von Neumann in his 1928 “Zur Theorie der Gesellschaftsspiele”, it was born as a new discipline in 1944 when von Neumann and Oskar Morgenstern published their book “Theory of Games and Economic Behavior”.

The structural resemblance of situations of economic or social interactions to parlour games had inspired von Neumann and caused the by now generally adopted name of the new theory. Several early extensions and novel contributions, mainly by John F. Nash, broadened the basis of game theory and enabled its inexorable progress.

Game theory is concerned with the analysis of purposeful interaction of individuals with partially conflicting interests in a group or society. It makes use of a variety of formal concepts and diverse mathematical tools. Considered as a sub-discipline of mathematics it is akin to geometry or probability theory in the sense that any of its models is tightly linked to a non-mathematical real world scenario, that is supposed to be understood via a careful analysis of that associated mathematical model and its due interpretation. The potentially different degrees of rationality, knowledge, information, skills and power of interacting individuals, their various interests and inclinations as well as varying institutional, legal or environmental frameworks generate an enormous variety of different game theoretic models. And there is an abundance of scenarios in the real world that may be modelled by such games.

The subdivision of game theory in different fields as cooperative (non-transferable utility; transferable utility), non-cooperative, Bayesian, stochastic, evolutionary, experimental

game theory and mechanism theory reflects its high flexibility and capability of reacting to specific needs arising from various problems.

Traditional game theory that is firmly based on the concept of an unrestrictedly rational homo oeconomicus and, according to the above quotation of Aumann and Hart concerns “the rational side of social sciences” may be reaching its limits. But this very fact is the cause for its expansion and extension to behavioral game theory, and thereby its crossing the borders of neighboring social sciences. The strength of game theory lies in its conceptual precision, its rigor and its consequent use of various mathematical methods.

Despite an almost identical vocabulary frequently to be found in sociology a wide ditch still separates large parts of sociology from the so called hard sciences. In contrast to the latter ones, sociological analysis is largely narrative and the argumentation is akin to that in philosophy, based on sanity and reason rather than on formal proofs or empirical data. Therefore, the sociologist Paul B. Hill criticises the representatives of (German) qualitative social research for their view, according to which the “infinite complexity” of action makes its description and explanation by scientific methods impossible. According to him that attitude makes sociology cease to be a science and slide down to feuilleton level. As a way out of this dilemma for sociologists he suggests the rational choice paradigm, basic to classical game theory, as a methodological base for an attempt to an explanatory general theory of action [see Hill (2000, p. 73)]. According to David Hilbert a scientific discipline that reaches a certain degree of maturity automatically falls into the realm of mathematics. Exactly this is happening presently to social sciences thanks to the development of game theory.

## 2 Social Sciences

The basic ingredient of a society is the interaction of individual entities. But while an analysis of this interaction and its determining conditions, and their mutual dependence would be considered part of biology rather than of social science its counterpart if the individual entities are human definitely belongs to the realm of social sciences like psychology, sociology, anthropology and economics. Needless to say that the borderline between both agendas is fuzzy and that there are plenty of behavioral similarities between humans and mammals, in particular primates, that imply transdisciplinary approaches.

In a human society the eternal controversy is what is more fundamental the individual or the society. This question roughly separates psychology from sociology and microeconomics from macroeconomics. Interdisciplinary dialogues have weakened the positions and stressed the possibility that neither one is more fundamental.

While this matter appears not to be the key aspect in positive or empirical approaches, it is an extremely explosive subject for normative theory. Whose interests and goals should be

more significant for the way a society organizes itself, social or individual ones, solidarity or individual values, law and order or individual freedom? This raises the question as to what are the norms of a society, how do they arise and what institutions develop or are created to enforce those norms?

We want to understand, how aggregate behavior of individuals creates institutions and how existing institutions influence individual behavior; how the size of groups or societies influences the way individuals interact; how rationality, customs and emotions determine human actions; when cooperation outweighs competition and vice versa; and how historical experience shapes a society's development. We want to understand whether new structures emerge from aggregate individual behavior and whether the program of reduction of social phenomena, that is the idea of a complete micro foundation, is sound and possible, at least in principle.

We may address all these problems and questions in manifold ways with different approaches and tools. And the degree of vagueness of description or formalization of the problems determines the degree of precision and reliability of the results. These may vary from aphorisms, transferring general wisdom to concrete, sometimes quantifiable results in specific models. It is the mathematical modelling that opens the way to empirically testable or formally provable statements.

Even if game theory by its concepts and results may stimulate also the more philosophical non-quantitative parts of social science, it is their latter model-based part that really profits from game theory.

### 3 Game Theory

Game Theory may most roughly be divided into cooperative and non-cooperative theory. The misleading terminology - it is the game that may be cooperative or non-cooperative rather than the theory - has become standard by now.

Non-cooperative game theory tries to extend a single individual's decision problem to a multi-person context. Identifying first for simplicity decisions and actions for a single individual a decision theory has to specify the individual's choice alternatives and his criteria for choice. Application of these criteria yields the individual's choice(s).

Adding the requirement of rationality, formalized dually, the decision problem gets more specified and is often tantamount to an optimization problem. This is usually described by an objective (or target) function associating to each of the available choice alternatives a value represented by a real number and interpreted as the individual's valuation of this alternative.

It is assumed that a rational individual chooses in such a way among its alternatives as to maximize the value of the chosen alternative. The set of alternatives may be restricted in several ways, among them the effects of actions of other individuals. As long as these other individuals are described only as parameters for the first individual's choice problem, we are still in the context of individual decision or optimization theory. Matters change drastically when we want to analyze simultaneously decision problems of several interacting persons, whose actions bring about mutual restrictions to each other's problems. Then we are in the context of non-cooperative games. These may be distinguished as simultaneous one - shot games, so called games in strategic form versus games with sequential moves of different agents, called games in extensive form.

Let me concentrate on the former ones. They are most clearly apt to show the fundamental difference from a single person decision problem. Imagine two persons  $A$  and  $B$  both having two choice alternatives  $a_1, a_2$  and  $b_1, b_2$ , respectively. Each person's choice is a parameter for the other person's decision problem. If both persons' values of their two available alternatives, given the other person's choice as a parameter, are described by real valued functions  $U^A, U^B$  we get four optimization problems:

The first one is: Maximize the value of the function  $U^A$  over the alternatives  $a_1, a_2$  under the parametrical restriction that person  $B$  chooses  $b_1$ .

The shorter mathematical description of this problem is:

$$\max_{i=1,2} u^A(a_i, b_1).$$

The other three problems are described similarly by:

$$\max_{i=1,2} u^A(a_i, b_2).$$

$$\max_{j=1,2} u^B(a_1, b_j).$$

$$\max_{j=1,2} u^B(a_2, b_j).$$

The problem is that the simultaneity of choices prevents each person to know what the correct parameter of his optimization problem is, as this parameter could only be known after the opponent's decision has been made. Now what are optimal decisions in such a situation? One may be in the fortunate situation that both persons' best choices are independent of their opponent's choices so that both have dominant choices. Such a situation brings us essentially back to two well-defined simultaneous optimization problems of the two persons. This may still cause fundamental interpretational or even philosophical problems. For instance, the famous prisoners' dilemma falls in this class of situations. But it at least solves for that special class how to define simultaneous optimality.

The situation becomes much more difficult when both players' optimal choices change with the parameters determined by their opponent's choices. Here the analogue for an

optimal choice of a single individuum is the famous Nash equilibrium.

It is a pair of choices  $(a^*, b^*)$  for the two players such that no other available choice for  $A$  would improve  $A$  in case of the parameter being  $b^*$  and no other available choice for  $B$  would improve him in case of his parameter being  $a^*$ .

Mathematically, in our situation this can be described by two simultaneous inequalities:

$$U^A(a^*, b^*) \geq U^A(a_i, b^*) \text{ for } i = 1, 2$$

$$U^B(a^*, b^*) \geq U^B(a^*, b_j) \text{ for } j = 1, 2.$$

It is important to know that these inequalities characterize the Nash equilibrium as the pair  $(a^*, b^*)$  that simultaneously solves the two maximization problems:

$$\max_{i=1,2} U^A(a_i, b^*)$$

$$\max_{j=1,2} U^B(a^*, b_j)$$

But this fact should not be misunderstood as meaning that  $(a^*, b^*)$  could in practice be determined by solving these two problems. Persons  $A$  and  $B$  are ignorant of their respective parameters  $b^*$  and  $a^*$  and therefore unable to formulate, let alone to solve, their problems. The possibility to characterize a Nash equilibrium as a simultaneous solution of several optimization problems does not enable the players to determine it by just solving these problems.

To get an intuition of what that way of solving the problem would mean imagine, that both individuals would need to solve some optimization problem to get their optimal choices but would already have to know the result of their opponent's problem in order to formulate the own problem.

So what is a game in strategic form?

There is a set of  $n$  persons, called players, say  $N = \{1, \dots, n\}$ . Each player  $i \in N$  has a set  $S_i$  of choice alternatives, called strategies. Moreover each player has a so called pay off function  $\pi_i$  that associates to any profile of strategies of all players his resulting value.

Formally a game is a list  $\Gamma := (S_1, \dots, S_n; \pi_1, \dots, \pi_n)$  with  $\pi_i : S_1 \times \dots \times S_n \rightarrow \mathbb{R} : (s_1, \dots, s_n) \mapsto \pi_i(s_1, \dots, s_n), i = 1, \dots, n$ .

The payoff  $\pi_i(s_1, \dots, s_n)$  for player  $i$ , if players  $j = 1, \dots, n$  choose  $s_j$ , is a real number. It may be interpreted as a payoff in any arbitrary medium whose quantity can be measured and expressed by positive real numbers. One specific way to interpret this payoff is as that players' utility (increment) induced for him by all players' aggregate choices of  $(s_1, \dots, s_n)$ .

Now a **Nash equilibrium** of the game  $\Gamma$  is a list  $(s_1^*, \dots, s_n^*)$  of strategies for the  $n$  players

such that  $\pi_i(s_1^*, \dots, s_i^*, \dots, s_n^*) \geq \pi_i(s_1^*, \dots, s_i, \dots, s_n^*)$  for all  $s_i \in S_i$  and for all  $i \in N$ .

There may exist one equilibrium in a given game, several ones or none.

Like in individual decision theory the existence of a unique best alternative is an exceptional case. So in general, non-cooperative game theory is plagued by a multiplicity of equilibria. That means prescriptions of how to act without any coordination or cooperation are in general impossible. Non-cooperative game theory has to confine itself to suggest what should be excluded from choice. There have been refinements of the notion of a Nash equilibrium, most prominently two versions of perfect equilibrium due to Selten. But they do not free non-cooperative game theory from this multiplicity problem.

The social environment, in which non-cooperative game theory is meaningfully applied, is one in that any kind of binding contract or commitment about actions is unavailable.

Lying and cheating is possible without sanctions. So a player's announcements and promises in a pre-play phase are credible only, if they are totally in line with his best interests. But if the latter can be computed or determined by rational reasoning the former are superfluous.

Yet, things are not happening in an unlegislated area. It is implicitly assumed that restriction of all individuals to their specified strategy sets is in principle enforceable and can therefore be taken for granted. So an oligopolistic firm's strategies may be described by certain price or quantity levels of production. Implicitly, use of brutal force and weapons in order to remove the competitors are illegal, and thus no available options.

Non-cooperative game theory is also able to handle situations of incomplete and asymmetric information of players about the realization of uncertain events and on their coplayers' specific characteristics. Payoffs become more complex then, as become strategies. The use of random experiments to determine mixed strategies and the evaluation via expected payoff or expected utility allows it to deal with those more complex situations in essentially the same way as sketched above. The Nash equilibrium in that context is called Bayesian-Nash.

The ability to formalize a concise optimality concept via an equilibrium notion in the context of multi-person interaction is a great achievement. It opens the way to a much more detailed and precise analysis of strategic interaction than a purely narrative approach.

But the assumed non-cooperative extremely competitive and self-centered environment of non-cooperative game theory is only one extreme case.

Another one is an environment where promises and contracts can be enforced and therefore be relied on. That is the context of cooperative game theory. Actions leading to



certain outcomes are assumed to be feasible and legal and vanish in the background. It is the contracted result, its social value and its individual values that is of main interest. Not individuals, the players, but groups of them, coalitions, play the main role in that approach. Achievements of coalitions are described in a stylized way by associated real numbers, interpreted as the worths of coalitions. The idea is that it reflects some kind of maximally achievable welfare of that coalition in the considered context. Without being made explicit a group's welfare or worth is an indicator of the utility levels the members of the group could achieve by acting as a coalition.

In a purely utilitarian tradition the worth of a coalition would be the maximum of the sum of its members' utility levels achievable via joint action. The use of a unique worth of a coalition implicitly assumes that worth may be shifted arbitrarily between the members of a coalition. Game theorists speak of transferable utility. If utility is not transferable what is achievable by a coalition needs a more complex description. It is a set of all vectors of utility levels of the coalition members that can be realized via joint action. But direct transfer of utility at universal rates is excluded here. The described distinction leads to a classification of cooperative games into transferable utility games, also TU-games, and non-transferable utility games, also NTU-games. The former may be easily modelled as special cases of the latter ones.

So a cooperative NTU-game in coalitional form for the set  $N$  of players is described by a coalitional set-valued function (or correspondence)  $V$  that associates with any non-empty subset  $T$  of players in  $N$  a set  $V(T) \subset \mathbb{R}^{|T|}$ , where  $|T|$  is the number of players in  $T$ .

Each vector in the  $|T|$ -dimensional set  $V(T)$  describes via its coordinates potential feasible utility levels for the members of  $T$ .

The ingenious idea of Nash (1953) was it, to formalize the concept of a solution for a class  $G$  of NTU-games, as a function (or correspondence) associating with any game  $V$  a (set of) vector(s) of utility levels for all players that could be achieved in  $V$ .

Now axioms expressing various notions of fairness, equity, justness or envy-freeness allow it to develop a normative value theory for cooperative games and to formally analyze the (non-) consistency of several concepts and axiomatic requirements.

The power of this more stylized approach to game theory lies in the fact that many different economic or social scenarios induce or generate in a natural way cooperative NTU-games.

The solution of the games can be traced back to certain states of the underlying social model that induce that solution. This allows welfare evaluations of social states agreed on via coalitional contracts.

## 4 Mechanisms and Implementation

While games, cooperative or non-cooperative, work with payoff vectors for the players, these may be interpreted as being in monetary or, alternatively, in utility units (“utils”).

Social choice theory is looking at outcome sets, interpreted as sets of possible social states, on which all agents of a given population have preferences or, to make it simpler, utility functions. That means that each agent evaluates each possible social state by using his utility function.

Finally, if  $N = \{1, \dots, n\}$  is the society and  $A$  is the set of possible social states, we have for all  $i \in N : u_i : A \rightarrow \mathbb{R}$ .

Social choice theory is concerned with the problem how to associate with any potential population from a prespecified pool of populations, each represented by its vector  $u = (u_1, \dots, u_n)$  of utility functions, a set of desired outcomes in  $A$ . Such a correspondence is called a social choice rule.

One may adopt the concept of an outcome set for applications of game theory. This concept is very flexible and allows various quite different applications. It could be, for instance, a set of feasible allocations of commodities or it could be the set of candidates for an election.

Using the concept of an outcome set  $A$  allows it to decompose certain games into its rules and its players' utility functions. Like a predicate robbed of its verb becomes a predicate form, a non-cooperative game in strategic form with the payoffs replaced by outcomes becomes a game form.

So imagine a whole class (or pool) of potential populations of  $n$  players, who all have utility functions on a certain outcome set  $A$ .

A game form, also called mechanism, is a list  $M := (S_1, \dots, S_n; g)$ , where  $g : S_1 \times \dots \times S_n \rightarrow A$  is called outcome function. Such an outcome function might be specified as a social rule or law, saying that whatever profile  $(s_1, \dots, s_n)$  any of those player populations would choose, once called for becoming active, the resulting social outcome would be  $g(s_1, \dots, s_n) \in A$ .

Now consider a specific population  $N = \{1, \dots, n\}$  of players. To decide what strategies they would use they would first look at the outcomes of their different strategy choices and then evaluate these outcomes with their  $n$  individual utility functions  $u_i, i = 1, \dots, n$ . Mathematically, they would compose the mappings  $u_i$  and  $g$  to build their payoff functions  $\pi_i$  via  $\pi_i(s_1, \dots, s_n) = u_i(g(s_1, \dots, s_n)), i = 1, \dots, n$ .

So they would de facto play the game  $\Gamma^M := (S_1, \dots, S_n; \pi_1, \dots, \pi_n)$  and solve it for a Nash

equilibrium.

Clearly, different populations of players with different utility functions would define different games from the same game form and, thus induce different Nash equilibria.

Now, the problem of mechanism design is it to create for a given pool of populations game rules, i.e. a mechanism, such that any population if called for playing according to these rules by playing a Nash equilibrium realizes an outcome that is desired according to a prespecified social choice rule. This way of establishing socially desired outcomes via strategic interaction in designed games allows many applications in contract theory, economic analysis of law and policy analysis. The designers of a constitution intended to work for countless future not yet known generations build a very illustrative example of the above idea.

We need one more step now to link cooperative and non-cooperative game theory using the above framework.

I imagine that the set of desired outcomes is always determined by the members of a specific population from the pool by solving a cooperative game. Technically this means that the payoff vectors prescribed by the specific ruling cooperative solution have to be traced back to the underlying special state or outcome that induces this payoff vector.

We may ask then: What kind of non-cooperative game in strategic form can via its Nash equilibria produce the same outcome and payoffs as the cooperative solution we started with? This research agenda has, following ideas of Nash, been called the Nash program. It is intimately related to mechanism theory (c.f. Trockel (2002)).

## 5 Multiplicity of equilibria

Many game theorists consider the general non-uniqueness of Nash equilibrium and its refinements a curse. I tend to consider it a blessing. To understand this, one better looks at dynamic non-cooperative games developing in time in a sequence of moves of the  $n$  players. Players may or may not know the exact previous choices of their co-players. All potential ways of playing such a game may be represented by a tree, similar to a decision tree of finite length, where at each final node a payoff vector describes each player's payoff in case the play ends here.

A book prescribing to a certain player exactly which move to choose, whenever it is his turn, represents a strategy. Putting these strategies together in strategy sets we come easily to a game in strategic form, a concept we already know. But the more aggregate strategic form game is less detailed and informative than the extensive form game we started with.

Now look at the extensive form game. By the whole sequence of moves each player reveals some of his intentions. If there is a unique equilibrium this may be unimportant. But say there are two. Consequently, choosing in accordance with equilibrium number 1 by player *A* may after a while impress player *B* and convince him of giving up his original intention to realize equilibrium number 2. Experience of stubbornness or insistence may play a role in determining the final outcome, even if both equilibria represent fully rational behavior of both players. The multiplicity of equilibria leaves room for the influence of other personal characteristics than just rationality. It leaves room for psychology and learning as crucial codeterminants of social outcomes.

## 6 Bounded rationality

Experimental economics has tested in countless series of different experiments rational behavior of individuals in single person decision situations as well as in various non-cooperative and cooperative games. The results are very much context dependent and do not transmit a unique general insight. Nevertheless, they give rise to considerable justified doubt that rationality is the right assumption for modelling individual decisions. These developments have led to consider bounded rational behavior of individuals formalized in various different ways. In principle, bounded rationality of interacting agents does not preclude the use of game theory. Rather than looking for optimal strategies or outcomes one may be satisfied with those fulfilling certain criteria. And there are game theoretical models where rational players are replaced by automata. Such automata need not be less rational than human persons, though. While deep blue, a chess program that defeated Kasparov in 1997, was lacking human intuition in estimating and evaluating situations in a play of chess, its computational power exceeded human abilities by far. A less computationally powerful program endowed with more human-like intuition was able to enforce a draw in a competition with Kasparov in 2003. Rationality is a high dimensional concept that therefore allows bounds of very different kinds. But game theory is able to handle bounded rationality and is supposed to even gain from the result higher flexibility in incorporating other criteria and aspects suggested from other social sciences than economics. Not surprisingly the Nobel prize for Economics of 2002 had been awarded to the psychologist Kahnemann and the experimental economist Vernon Smith. Some caveat is appropriate, however, in judging experimental economists' claim that most standard game theoretic solutions tend to be not realized in experiments. Apart from framing effects that experienced experimenters are able to avoid the experimenters never know for sure whether the solutions they set out for testing are computed from the correct utility functions of the participating players. And if payoffs are in money the same solution concept might result in different utility payoffs, for different individual utility functions. Some game theorists, therefore, suggest to develop a theory of revealed preferences in games in analogy to that of the microeconomic theory of consumers (cf. Zhou and Rey (2001)).

But experiments have provided valuable insights about what determinants apart from pure rationality are responsible for human decisions and how specific contextual features may influence the outcomes. All this is part of the dialogue game theory had started with other social sciences.

## 7 Evolution and learning

Game theory has turned out remarkably successful in evolutionary biology and insights gained there have been used in models of learning in social contexts. Evolutionary biology uses the formal concept of a non-cooperative game, static as well as dynamic, in an unconventional way. There are no players, who choose strategies in order to maximize some monetary or utility payoff. Rather a random device picks two representatives from the two strategy sets of a given strategic form game, who have to “play against each other”. Both strategies matched to each other automatically produce the payoff vector, whose two coordinates are determined by the given game. The payoffs interpreted here as “fitness” of the types of strategy, increase the probability of that type to be picked randomly in a next round. Here “nature” chooses randomly pairings of strategies (types) and the resulting payoffs determine the survival probability of those types in the varying pool of strategies.

Interesting enough, such models of evolution or models of learning, in some sense akin to them, frequently result in outcomes that correspond to equilibria of real strategic games or solutions of cooperative games (cf. Young (1998)).

## 8 Conclusion

The variety of models and applications might have conveyed an impression of the power and richness of game theory. There is hardly a social phenomenon that is not accessible via game theoretic modelling. Clearly, it should have become clear by now that game theory is not the unified general theory of human interaction in the society. It rather is a tool chest, full of methods, concepts and devices whose applicability and effectivity vary and depend very much on the concrete context or framework.

Its mathematic nature is very powerful in providing clear insight into what results depend on what kind of assumptions. The mental or conceptual resolution induced by the use of mathematics is a clear advantage for any attempt of thorough understanding of the fundamental social phenomena. Let me give an example supporting this position.

In his booklet “Soziale Konflikte” Ansgar Thiel (2003) is also treating game theory as one

of the existing approaches. During his discussion this author identifies “two-player games with strictly opposed interests” and “two-person zero-sum games”. Comprehensible as this view may be for the formally untrained it distinctly demonstrates a lack of resolution for which one should not reproach this specific author but rather the apparatus he is using for his analysis.

Clearly a two person zero-sum game, which is characterized by the fact that the payoffs of the two players  $A$  und  $B$  add up to zero, whatever their strategy choices are, is a game of strictly opposite interest.

But now consider a different game derived from the previous one by letting any negative payoff of both players be the same as before and taking the positive payoff of one player to the square. The interests are still strictly opposite, but the game is not any more a zero-sum game, unless in the original game all payoffs were only 0, 1 or  $-1$ .

But this is not the end of a sharper look at opposite interests. In contrast to what Thiele claims the payoffs of the two players need not even be summable in any meaningful way. The description by real numbers of a social phenomenon does not justify to perform all operations that are possible for real numbers. They must be checked on their admissibility as an interpretable operation in the underlying social model. For instance, if player  $A$  receives his payoff in apples, player  $B$  in oranges, where negative amounts mean a duty of delivery, summing up is not even meaningful. Nevertheless, if whenever a change of strategies that increases (decreases) the amount of apples  $A$  receives, simultaneously decreases (increases) the amount of oranges  $B$  gets we have strictly opposite interests, provided the players like their payoffs.

The strict use of formal argumentation as a reliable device to ensure correctness of arguments may be sometimes incomprehensive and considered even a provocation by people with a different methodological background. But it has the merits that it allows to replace plausability arguments by propositions that may be proved or disproved.

A mainly verbal treatment of social phenomena and social interaction is like a translation from a foreign language without sufficient knowledge of the vocabulary and the grammar. It may offer a suitable rough description but can hardly produce a deep detailed analysis.

I think game theory can play the role of the language of social science but as any living language it has to be open to permanent change, to absorption of new concepts and methods and to the adoption of parts from other languages (disciplines) when itself fails to offer an adequate term. And as any language it cannot be learned without a certain effort and the readiness to exercise. The payoff for starting to use game theoretic language will be a more effective and more precise scientific communication.

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