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I.

When Walras set out to formulate his system of simultaneous equations purporting to describe the complex interrelations among prices and production, economics took a great step forward. He was naturally guided by the ideas latent in modern mechanics and made possible for representation by the appropriate mathematics of the time and the subject matter. It would be most extraordinary if the simple model used almost 100 years ago could remain unchallenged. The economy is too complicated and has too many facets, so that it is natural that models are superseded, both because there are changes in the economy itself, largely due to a rapid development of technology, and because better descriptions are obtained even of phenomena that are little affected by technological change.

But whatever the changes, the problem remains to what extent the social sciences can be modeled, or should be modeled, after the natural sciences. The question is made more difficult by the fact that mechanics is no longer the sole, nor indeed the principal part of physics. The rise of relativity theory and quantum mechanics brought profound changes. Other natural sciences, such as biology, have opened up additional, novel fields. Thus it is not <u>a priori</u> clear which of these various disciplines of the natural sciences is to serve as a prototype. Perhaps none of them should. There

have been economists who would rather see us follow biology than mechanics; yet since the time when this was proposed, biology itself has undergone such astonishing changes that it is not clear whether those earlier writers would still adhere to their own precepts.

There is one aspect of physics which is certainly of the highest importance and where there cannot be any doubt that the social sciences should follow: that is the establishment of scientific <u>standards.</u> There is tradition and experience in theory formation, in critical evaluation of data, of experiments, and profound knowledge of the difficult role of measurement. To establish a new fact in physics is anything but easy. Compared to this the social sciences have always taken and still take too much for granted, have no comparable standards of making and evaluating observations - let alone experiments, though such are certainly possible over wide areas. The better the social sciences - including ethics and law - emulate the physical sciences in those respects, the surer will be their progress. However, this tells nothing about the varying structure of these fields, where, indeed, great problems lie. These problems do not arise only from the uneven speed with which different sciences progress which makes their comparison difficult. Their unfolding and steadily increasing differentiation confronts anyone who would like to show parallels with, say, economics, with increasing difficulties and possibly with the need of revising his views from time to time. If that is so, a parallelism is probably spurious since it is most

unlikely that the development of economics would follow precisely that of the other chosen field.

In what was said above there is so far no conflict with the view expressed by M. Rueff in his astoundingly impressive and fruitful early book "From the Physical to the Social Sciences", 1922, when he says: "All sciences are rational sciences like geometry, and, since there is a deep seated similarity between the social sciences and the other sciences, there is nothing to prevent us from presenting ethics and political economy under rigorous scientific form." The most rigorous of these forms is mathematical. But there is not one single mathematics; there are many branches some of which have evolved in closest connection with the various empirical fields in which they are primarily used. This process is hardly finished today when so many new sciences arise which all call for mathematical analysis. It is well known how the discovery of the differential calculus is inseparable from the growth of mechanics, or how quantum mechanics is intricately tied up with certain developments in matrix calculus and operator theory. Yet, the matter may well go much farther. For example, it has been shown by G. D. Birkhoff and J. von Neumann that some sciences may even have their own logic, such as "quantum logic", which in this case quite specifically is represented by a projective geometry in which the distributive law does not hold. It is highly probable that similar developments will occur in other fields, bringing about a much greater differentiation than can be seen today. This may even

happen in economics and political science. Indications for such a development are becoming more pronounced; an example is perhaps offered by the logic of the putative and the logic of normative systems. Thus, similarities, plausible perhaps at one time, may cease to be so at another. In that sense, Walras' effort would undoubtedly be subjected to significant modifications arising from this angle. There are undoubtedly depths - to use M. Rueff's term - at which there are similarities, but they may be very far from the surface at which the current work is going on.

Furthermore, some similarities may be only apparent because the economic phenomena have not been adequately described. Indeed, it will, in general, be very difficult to give proper descriptions. For example, "utility" has for centuries been conceived of as some kind of an inherent quality of goods. It took a long time to see that there exists nothing of this sort, that we can only speak of preferences and that the whole basic problem of measurement of utility can only be solved by adopting this new and different way of looking at the old phenomenon of economic "value".

More important, the fact that the individuals composing the economy act intentionally either co-operatively or in conflict with each other, leads to the recognition that in economics ordinary maximum problems do not as a rule occur. This in turn throws into doubt to what extent the differential and integral calculus, designed specifically for dealing with maxima and minima, is the appropriate mathematical technique for economics. On the ability or inability to represent the economic problem typically as one of

maxima and minima, with or without constraints, however hinges a great deal of the alleged similarities with physics. Molecules and atoms do not cooperate or fight each other: they either attract or repel each other. While superficially this seems to be the same thing as cooperation, or combat, the differences are greater than the similarities.

The fact that men in all their activities are inevitably involved in fights and cooperation and sometimes simultaneously in both in a very complicated manner is probably the most important phenomenon that social science has to explain. Elements of such behavior occur also among animals but never in inanimate nature. The theory of games of strategy is designed to analyze many of these basic relationships and has a logical-mathematical structure which sets it apart from the Walrasian equilibrium construct. The latter appears only as a limiting case of no great empirical relevance.

II.

"Rational theory" refers thus to method. There can be no doubt that we want our theories to be rational - where this word essentially means that they would ultimately be subject to mathematical analysis and predictive proof. "Rational behavior" of men, however, is a different matter: here the word "rational" refers to something else besides mathematical, or "geometrical" analysis (as M. Rueff says, in the great French tradition of using this term). The concept indicates that optimality is looked for in the

acts of an individual or a community. I shall not discuss whether and how this optimality can be assured; I shall only point to one pre-requisite which is that there must be a prediction of the consequences of different acts.

The individual must have information about the reaction of nature and of his fellow men whenever he decides to act. He must know his environment. The information may be good or bad, will be based on his ability to interpret it, on past experience, on common sense as well as on scientific analysis. Out of this conglomeration comes the prediction which then leads to the decision of either accepting or rejecting a given course of action until the optimal one is decided upon. This is the one which cannot be improved upon; it is a course for which every possible course of action by any others, involved in the same situation, has been considered in their effects upon the given individual himself.

As far as (human) opponents are concerned the individual cannot make statistical assumptions about the opponent's behavior: a chess player would certainly lose if he did this, as well as any general would be beaten in a battle. But vis-a-vis nature, statistical assumptions of the current kind are thought to be adequate when trying to assess nature's behavior or nature's reaction to one's own acts. Here taking a statistical view expresses merely a lack of <u>detailed</u> knowledge in an ultimately deterministic situation: there is no objection <u>in principle</u> to our knowing the movement of all molecules in a gas; but it suffices to know it only statistically. (Observe that this does not apply to quantum mechanics, where it is <u>in principle</u> impossible to make

transformations of this kind.) Thus we are willing to accept uncertainties; indeed, for practical reasons we have no other choice; but we wish to minimize them. This can be done only if a sufficiently firm framework is given within which the events must fall with certain probabilities. There are thus statistical uncertainties which are due to nature; and there are uncertainties in social communities, some of which are of types occurring in nature, others which are different, since they are caused by the actions of those players in the game with whom we are directly involved since they have a perceptible, tangible influence upon the outcome of our own actions.

These are, admittedly, delicate and intricate intermixtures of various ways in which uncertainties and statistics have to be considered by an economic individual. But there is no way of simplifying the situation. On the contrary, there is a further complication which could arise if we should have to assume that nature is not necessarily friendly to man, as shall be discussed in the next section.

III.

The purpose of the prediction is the evaluation of our acts, first from the point of view of their effectiveness in view of a given goal, such as the desired profit or utility; second with respect to their legality and moral or ethical character. The latter aspects may restrict our choices.

M. Rueff rightly emphasizes the need for a rational theory of ethics - a goal still unfulfilled, although over the last decades, mainly with the aid of modern logic, we have recognized the often tautological or even self-contradictory character of most ethical systems. This is clearly the first step for building axiomatically clean constructs for the world of norms, which is ethics as well as law.

The predictability of the natural and social world involves a statement about the attitudes nature and man take towards us when we try to explore them (if, for a moment, we separate the two). Man's behavior: that is mostly hostility: "homo homini lupus"; i. e., the pursuit of one's own interest conflicts often with the interests of the others, even though there are important phases of parallel interests and of cooperation upon which human organization and progress depend. Nature, however, may be benevolent, or at least indifferent, to us. Nature is generally not considered malevolent to man.

We have to decide which of these three possible attitudes of nature is true since this determines how we approach nature, either as scientists or as the source of our life and well-being in our daily behavior. But can we make a decision? What evidence do we have? Einstein thought, as is commemorated in an inscription in the Mathematical Institute of Princeton University: "The Lord God is sophisticated, but not malicious."

The views of this great man who has advanced our knowledge of the universe in decisive ways are certainly important, but doubt remains whether

any assertion of this kind can be proven. It is ironic that in American law natural disasters, destroying men and their property, are labeled: "acts of God", not, as one might assume, as "acts of the Devil", the latter - at least as a natural force - having vanished from the sight of western man for quite some time. Among statesmen and politicians, however, he is still making frequent appearances.

The idea stated by Einstein is, of course, not new. Already Heraclitus has said that hidden harmony is superior to the apparent one, that nature neither states nor conceals, but "gives a sign", as was the policy of the oracle at Delphi. Elsewhere he asserts that "nature loves to hide". Nature certainly has given us confusing signs. The history of science shows how we have stumbled from one wrong interpretation to another before finding the present truthful descriptions. Will they stay so or are they again only stepping stones? Yet, Descartes and Bacon expressed the idea of the veracitas dei which has become, more or less the philosophy underlying modern science which at least tacitly excludes the possibility that we are being misled by "nature".

An important exception is offered by Poincaré. The famous Michelson-Morley experiment designed to determine the "ether wind" gave no evidence of its existence: the velocity of the earth through the ether could not be detected. Poincaré ascribed this to a law of nature which is that nature is in a complete conspiracy making the discovery of the phenomenon impossible.

The device nature used, was thought to be the change in the measuring instruments during the experiment itself. If it occurs, it is surely a process of great subtlety.

There is no doubt that nature is not treating mankind kindly when we consider how we are tightly restricted to the extremely narrow confines of temperature, radiation, air pressure, air composition, to body temperature and balance of chemicals within our bodies. The slightest - especially rapid - variations can mean death or illness or inability to procreate. Survival of the human race is at any rate a delicate issue, even if we abstract from the novel fact that humanity recently has acquired the power to do away with itself, a power it may foolishly exercise some day.

On the other hand, nature is clearly benevolent to us in that it has given us senses and organs with which to discover nature itself, to reach into the far confines of the universe and the atom. It could be quite different. Very slight changes in our capabilities might have prevented us from discovering what we have discovered. Who can say whether other slight increases in these capabilities might not have led to the discovery of phenomena which are forever inaccessible to us?

It is possible - and that is our hope - that over the millenia we shall, in an ever converging process, press closer and closer to the ultimate truth as to a pole (as understood in the theory of functions) and that we shall also develop the insights and talents to use our increasing knowledge to the benefit of man - provided we are able to state where the benefits lie. One

can hardly escape the impression that we are rapidly approaching such a pole - with the possibly disastrous consequences of such an event - if we look at the incredible speed and profundity of change which describes scientific development of the last few decades, a speed that seems to be accelerating.

But the question remains - and, indeed, the suspicion rises - whether we are being misled by nature into accepting pictures of the world (or "equations", if one prefers to put it that way) and assuming powers which ultimately will confuse and destroy us. The salient fact is, as is often bewailed by knowledgeable men, that our knowledge of the physical world increases at an incredibly faster rate than our ability to cope with that knowledge. This same speed has now even taken hold of the life sciences but there is no sign as yet that even the foundations have been laid for a science of politics. Yet, it is in the political domain, giving it the wide interpretation as referring to the government of humans by humans, where our fate is being determined. One cannot forget the famous remark made by the Swedish Chancellor Oxenstjerna to his sons about the astonishing stupidity of governments: "Videbis, filii mii, quam parva sapientiam regitur mundus." Though in some respects there is an improvement, events of the last few decades are not reassuring.

The difference in speed of development of the natural and social sciences may be the very trick of nature by which to doom man so that we make room for another species with which nature can amuse herself.

With our present knowledge it is probably impossible to say what nature's attitude is, or where we must delineate "nature" for the purpose of such a statement, i.e., whether to include man or not. Yet, this is no idle question since on the answer depends the choice of method how to approach nature in order to satisfy our scientific curiosity.

Perhaps we should no longer talk of "nature" but rather see before us a mass of random processes which together generate the phenomena we call "nature". Surely we want to go beyond animism or other personifications. But there is no way of ascertaining now whether we should go the whole way towards assuming complete randomness. The odds are against this idea but proofs are lacking. So we stay with the idea, which even Einstein and Poincaré accepted, that there is a "nature" about which statements of the above kind can be made which surely would make little sense vis-a-vis purely randomized processes.

IV.

I now turn back to the relation between rationality and prediction. M. Rueff maintains rightly that social science should be able to determine the "rational ego". This has been a concern of social science for a long time and is inseparable from the particular embedding of the individual's actions in a moral context, whatever the particular definition of morality may be. In order to behave morally, the <u>moral</u> implications of acts have

to be assessed with respect to the future. It is one thing to determine the moral value of acts in this manner in a strictly static universe and another to do so for a dynamic situation, i. e., either for a world with quantitative change of existing things or for a world into which new things enter which have not been foreseen by the creators of moral codes.

One way out of the dilemma of prediction is to follow Kant and to say that morality depends only on the reasonable prudence of the actor; i. e., he can only be expected to have a view of the consequences of his actions corresponding to his intelligence, education, experience, position in life, and so on. Even better, some philosophers see no need at all to predict consequences. For them there exists apparently some absolute knowledge of what is good and bad. But for this there is no practically useful proof, given the impossibility of classifying by means of a catalogue in advance all acts a man may have to set or to do so on the basis of a principle at the instance when they are being made. Even in a static universe, man as an individual is always confronted with situations which are new to him as a person, though they may be commonplace for the human race, and therefore he can bring no personal experience to bear on his problems. Thus we cannot avoid the need for making decisions, which is to choose from alternatives and to recognize that the outcome of the choices is often associated with uncertainties of the types discussed above.

The fact that a complete catalogue classifying the moral value of all possible situations man or society may have to face is impossible is

demonstrated by the practice of law. There catalogues are made which classify actions as permissible or forbidden. But judges are needed to interpret many situations or to discover which principles - applied in the catalogue - are to be used for situations not already contained in it. If there were courts of morality as there are courts of law, the persons having recourse to them would find it just as difficult in many cases to predict moral decisions as it is notoriously difficult to predict the outcome of law suits.

When the morality of our behavior cannot be known in a deterministic manner but is only known stochastically, a new situation arises for ethics which, as far as I am aware, is not explored. This is not the same situation dealt with by the so-called "probabilism" of the theologians of the 16th Century although there are some relations to their thought. It will be impossible for the science of ethics, which also M. Rueff postulates, to escape dealing with uncertainty in a fundamental way. It will mean, among other things, that the moral consequences of actions can only be known statistically and consequently moral commitment would not be definite but only approximate!

As M. Rueff observes, for the decision making individual Bentham demanded "certainty" as one of the seven quantities he believed compose pleasure, and Mill advised that in order to find out which of two pleasures is greater, and therefore should be preferred, one should rely on the judgment of those who have experienced them. The first author closes his mind to the phenomenon of uncertainty, the second excludes the novel and furthermore assumes without qualm that the experience of the greater-smaller

relationship of pleasures is communicable from one individual to the other in some objective manner. No proof that this is possible has been found to this day.

While thus the individual is always in trouble, given the above circumstances the state in making economic policy, often reaching into an indefinite future, should have a maximum of foresight surpassing that of any individual or any other organization because the total of all the citizens' intelligence, information, and acumen is at its disposal. This is clearly only an abstract idea; in reality there is no guarantee that the State's decisions could be viewed in this light.

Even if there were none of the above problems the morality of decisions must involve the element of time. This issue is usually skirted. How far into the future does moral responsibility go? Certainly some time is involved. But some acts, in order to unfold, need much time, others very little. Is there a uniformly applicable time-span for all men, or does this depend on their position, power, intelligence? On the magnitude of the act? Was it really irresponsible to say "apres moi le deluge"? Or was it so because the absolute ruler of a great nation made this statement? One looks in vain for thorough exploration of these and related questions in the large literature of ethics where far too little effort has been made to come to quantitative and logically consistent non-tautological statements.

Consider as an illustration the Romans who cut down the forests in Dalmatia in order to build the ships with which they secured their dominion

throughout the Mediterranean. As a consequence, the climate of the country was changed and great hardship wrought for generations up to our time and beyond. The Romans did not know that these effects would occur; they were judged on the basis of the knowledge of their time. But we know more and we judge the consequences and perhaps the Romans differently; yet, our views are irrelevant to people who lived more than 1000 years ago. Today we have similar situations: we deplete the world's oil and mineral resources without any thought of the dire consequences for future generations. We believe our need to be great and our actions justified. In other words, we discount the future even in regard to morality - strange enough process if put in these terms. But there is no better one. It is odd, however, that this disregard of the future in order to be stated at all requires an economic concept, i.e., that of a "discount", though we are primarily asking about the moral aspects of decisions.

It is a realistic description of human behavior that the future is considered less than the present, though the exact formulation of this phenomenon is far from simple. That we are mostly concerned with the present and the more immediate future is possibly explained by the fact that in many circumstances we could not act at all if an indefinite future were to be taken into account, <u>even if known</u>. It is easy to point to examples where we would have to forfeit our lives in order to prevent some damage to future generations, damage we would otherwise not willingly inflict upon the present.

The notion of discount gives rise to a peculiar paradox: economic decisions must, as was shown above, be embedded in some moral framework without which no society is possible. Yet, this moral framework cannot be described without recourse to some economic concepts. This forces us to look eventually for a theory of decision making which comprises both. The current views of economics as being independent from value judgments may prove to be just as limited as corresponding ideas that ethics is independent (or even superior) to economics.

While time gives one dimension to moral decisions, another quantity, distance and numbers of men affected by our decisions, provides another dimension. It too is little explored. Events taking place at great distance assume a different moral value, positive or negative, than the same happenings close to home. Our new weapons which can reach any point on earth without our observing the horrible consequences are more easily set into motion against innocent women and children than far less lethal devices wielded against a deadly enemy we encounter face to face. This very fact constitutes one of the greatest dangers of our time. Similarly, we tend to neglect the moral implications when the weight of our actions is small in comparison to the aggregate phenomenon. For example, many who bewail the increase in world population will not hesitate to produce large families since their own contribution is negligible in the sum total. Similarly for side-effects of machines introduced into our life, through noise, contamination

of the air, pollution of water, etc. These questions reappear if the economist's notion of the "Pareto Optimum" is examined closely.[1]

We see, at any rate, that morality involves time horizons and spatial-numerical factors, and these are likely to be of different length or size for different actors and situations. If our foresight, based on a better understanding of causal relationships were to reach farther we might, on moral grounds, behave differently. Is nature tricking us into a pattern that assures the deprivation of future generations, possibly their destruction?

V.

I shall now return briefly to the question of nature's attitude to man and its significance for the structure of science. If nature is indifferent to man or even benevolent, we may proceed with our methods as we have done; but if there is a suspicion of hostility, our approach would become most difficult indeed. Instead of using pure, direct strategies in questioning nature we would have to develop different ideas, perhaps similar to those needed in social science, where often an indirect approach is needed in order to elicit the truth from the subjects studied and to avoid the contamination of the observer due to his immersion in the society he studies. Anthropologists are well aware of the fact that their presence changes both the society to be

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[1] I have discussed some of these issues in my paper "Pareto Optimum and Social Organization", in: Systeme und Methoden in den Wirtschafts- und Sozialwissenschaften, Festschrift für Erwin von Beckerath, Tübingen: J. C. B. Mohr, pp. 573-586, 1964.

studied and the observer himself because of his contacts with the former. In the natural sciences very subtle events have also occurred severely limiting the power and role of the observer. The most noteworthy is Heisenberg's uncertainty relation. Another outstanding case is the Michelson-Morley experiment and Poincaré's interpretation, referred to earlier. As science becomes more complicated we may perhaps expect further surprises of this kind. It is therefore, I hope, not idle to introduce the questions raised in this paper. They presented themselves in re-examining the early work by M. Rueff which deals with a topic that is as fresh today as it was over 40 years ago. It will occupy the learned world for a long time to come.