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Further Thoughts on Scientific Method As Applied in Economics

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IN AN EARLIER PAPER[1] we discussed various methods of inquiry that men have used. These included magic, revelation, common-sense observation and accumulation of the results as folk lore proverbs, Platonic idealism or the dialectical quest for certainty (which is in some respects a sophisticated form of word magic), classification and the syllogistic quest for certainty a la Aristotle, and finally study of the relations among changes as initiated by the Galilean revolution in method. Of course, we do not imply that each of these methods has always been clearly separated from the others, nor do we imply that at any time and place any one of these methods has been applied in a pure form without vestigial carryovers from one or more of the other methods. Moreover, one cannot place these methods in a neat chronological series. One can only assert that at various times one or another of these methods, judging by the historical record, seems to have been more widely accepted than others and thus to have dominated the prevailing intellectual climate.

For example, a few thousand years ago various magical procedures were widely used as means of facilitating prediction and control. But at the same time research was in progress that involved study of the relations among changes. How else can one explain some of the artifacts of the ancient world such, for example, as the copper plumbing in Roman baths? Presumably, someone experimented with copper ore, heat, etc. However crudely, he or they presumably measured changes and studied the relations among those changes.

[1] "What Is Economic 'Knowledge'?" *Am. J. Econ. Sociol.*, 13 (January 1954), p. 113 *ff.*

And today one can find even in the scientific journals avowals of faith in one revelation or another. One has only to look around to see that the Galilean revolution in method has been accepted as the best method of inquiry by only a small fraction of the world's population and that many, perhaps most, of even that small fraction lean heavily on other methods of inquiry whenever they seek to know about other matters than their own fields of specialization.

Thus we are faced today with the fact that no clearly defined method of inquiry is universally accepted as the best in all fields. Even the striking success of the Galilean revolution in greatly augmenting the ability of men to predict and control events in the fields of the natural sciences has not greatly altered most men's views on method in spite of the great alteration in the environment that has occurred in modern industrial societies. Men are prone to accept their cultural heritage uncritically, and this is as true of the automobile as it was of the Roman chariot. In short, to many, the scientific advance does not reflect the triumph of a new method of inquiry but the happy coincidence of a series of fortunate inventions; and the latter, where they are not regarded as evidence of a devil's favor, frequently are regarded as evidence of luck plus perhaps pertinacity.

Now it happens that the present writer has accepted the working hypothesis that the Galilean revolution and subsequent developments in methods of inquiry provide the most useful procedures from the viewpoint of facilitating prediction and control. Prediction of future developments and control over them, at least to the extent of behavioral adjustment to them, are accepted for the purposes of this discussion as the immediate ends in view of inquiry. We put aside for the moment (but do not of course deny the existence of) other ends of inquiry such as (for example) aesthetic satisfaction for the inquirer.

The questions that we now propose to discuss may be stated as follows:

1. How is the method initiated by the Galilean revolution different in principle from the methods of inquiry used earlier?
2. How has the new method developed in various fields?
3. What aspects of the new method are applicable in economics?

The Galilean Revolution

THE REVOLUTION IN METHODS of inquiry that was exemplified, if not actually initiated in all detail, by Galileo's work involved one great and obvious departure from the methods previously popular and a second less obvious but equally important departure from earlier methods. In the order just indicated these new procedures were, first, the selection of changes as the subject matter of inquiry and, second, the abandonment of what John Dewey has called the "quest for certainty" and substitution of the attainable goal, a high order of probability, or warranted assertibility. Brief comment on these new methods and their relation to each other may be helpful.

The Greek philosophers sought to know the unchanging and everlasting reality. More precisely, they imagined that there must be such things as eternal and immutable reality of some kinds, types, or forms; and their methods of inquiry were adapted to the pursuit of their imaginary objectives. In labeling those objectives imaginary, we do not here imply that there necessarily is no ultimate, unchanging, and everlasting reality; we imply only that to date those who have thus quested for certainty have not been able to convince other intelligent men that they have found it, nor have they been able to demonstrate that the methods of inquiry developed in the course of that quest have been as useful[2] as more modern methods of inquiry.

Now it is hardly surprising that men seeking for the eternal and immutable considered change unworthy of serious study. How could any reasonable man expect to find unchanging and everlasting reality undergoing change? That this seemingly sound viewpoint was reinforced by the culture of their times is well brought out by Dewey and Ratner in particular.[3] For our purposes here, we need only to note the fact and pass on.

When Galileo chose to ignore the refined objects of reflection, and insisted on turning his attention to the macroscopic subject-matters found undergoing change in primary experience, he spurred on the revolution in method. To turn aside from the traditional and accepted mode of procedure in inquiry, to drop dialectical debate as though it were a useless appendage would have seemed hopelessly unsound to the scholastics and their Greek progenitors; and to have chosen change as the subject matter of inquiry, even to have initiated more changes for the purpose of studying the relations among them, would have seemed incredible folly. Of course, the Greeks were not stupid; they were keen observers of quali-

[2] We should judge the usefulness of a method of inquiry by the extent to which it made possible control over events including either behavioral adaptation as part of the events, or external changes outside of any human organisms, or both.

[3] John Dewey, *The Quest for Certainty*, New York, Minton, Balch, 1920; and Joseph Ratner, ***Intelligence in the Modern World, John Dewey's Philosophy***, New York, Modern Library, 1939.

tative differences, and they were enthusiastic about mathematics. Its rigorous "laws" seemed to them an ideal tool for use in their quest for certainty. They simply mistook a short-hand method of transforming propositions for a means of probing reality:

Modern scientists, however, began by taking precisely the world of change as their subject for scientific study, and to help them on their way, they introduced the method of experimentation which is no less and no other than a method whereby the natural changes going on can be further increased and complicated in manifold ways by changes deliberately made. From the Greek point of view (and in this case, *not* excepting any Greek), this is confounding confusion, science gone insane. But as events have fully demonstrated, it is science really come to its senses, and intelligence come into its own.[4]

However, the quest for certainty was not so readily put aside. Although the methods used by those who had sought certainty were abandoned as the new method of studying change was found to be effective, the objective, ultimate and unchanging reality, lingered on in the minds of men. Newton, the intellectually gifted philosopher-scientist, was convinced that he had at last found certainty behind the facade of change in the form of his atom, his "absolute and separate Space and Time, and immutable (invariant) mathematical laws of Nature."[5] Not until Einstein's work and Michelson's finding of the black bands in his interferometer was the quest for certainty finally discredited in the realm of science. (That all too many scientists are still unaware that the revolution in method spurred on by Galileo has thus been brought to maturity is too obvious to require further discussion.)

Development of the New Method

As HAS BEEN INDICATED, the new method differed from the old in that the modern scientists of the past three centuries have turned to study of changes and the relations among changes. Now changes may be of two general types or a combination of both. These have been designated qualitative and quantitative; and examples of each probably will be more illuminating than definitions.

During his early years, a male human organism may acquire the habit of wearing a hat as protection against the sun and discarding his shoes during the summer months, the typical barefoot boy. In later years the matured organism may substitute for the earlier habit the habit of wearing shoes and discarding a hat except in inclement weather. This is perhaps as clear an illustration as can be given of qualitative change.

[4] Ratner, *op. cit.*, p. 52.
[5] *Ibid.*, p. 107.

An example of quantitative change is provided by the fluctuations in the price of wheat. Wheat at $2 per bushel has experienced a quantitative change in its exchange value aspect from the same wheat at $1.90 per bushel, and the difference in the price is the measure of this change.

As it happens, however, qualitative and quantitative change are not always separable. Thus the traffic light that changes from green to yellow to red may seem to provide a clear example of qualitative change until the colors are expressed in terms of the rate of vibration of light rays per second. Then it becomes obvious that the changing traffic lights may be viewed as an example of quantitative change or even of the two combined.

Similarly, to the layman the music of a bass viol may seem qualitatively different from that of a piccolo; but to the physicist the difference may reflect quantitative change measured by vibrations of sound waves per second. Thus the modern scientist, although he does not ignore qualitative change that cannot be transposed to measurable quantitative change often may emphasize other aspects than the qualitative changes that seem important to laymen.

If one follows through developments in the various sciences, from their earlier beginnings as such to the present day, quantitative change is seen to receive increasing emphasis as the subject matter of inquiry. From one point of view, it might be said that the scientists apparently never will be satisfied until they have succeeded in developing the quantitative aspects of all changes. However, this perhaps is too broad a generalization. For our purposes here we may simply note that increasing preoccupation with quantitative change including the conversion of qualitative change to quantitative change is an outstanding characteristic of modern scientific method.

Now quantitative change is measured change; that is, we recognize that change has occurred by measurement, however crude that measurement may be. In some instances the measurement may be so crude that the changes are stated in such inexact terms as greater or less, higher or lower, faster or slower, longer or shorter, etc. What was larger has become smaller, high speed has been retarded, rising prices have changed to falling prices, what used to require a week can now be done in less time; these are examples of rough measurements of quantitative change.

As everyone who is familiar with any of the sciences knows, measurements of change may be much more precise than those mentioned above. For example, changes in the currency in circulation daily in the United States can be measured with a degree of precision that greatly exceeds the degree of precision with which many people would trouble to measure the changes in the coins in their pockets from one day to the next. Changes in the relative positions of a distant star can be measured with a degree of precision that few housewives would have occasion to apply in measuring their peregrinations about the kitchen floor.

Scientists are concerned with measurement of change as a means or as one step in their work. The immediate end in view or purpose of such measurements is to facilitate the study of relations among or between the measured changes. Based on their familiarity with such changes, scientists develop hypotheses or statements of the relations believed to exist. In turn these hypotheses are developed in theory in order to find implications that can be tested by returning to the measured changes. Out of such tests come new or improved hypotheses, more implications that can be tested by returning to measured changes, and so on *ad infinitum.*

Obviously, if one wishes to measure changes, his task *may* be greatly simplified if the changes can be started and stopped, accelerated and retarded, as the measurer desires. Consider, for example, the moon and the tides. Measurement of their respective changes and study of the correlation that is found can hardly be done thoroughly in less than a month, and a substantially higher degree of precision might require observations and measurements extending over several years. If one could control the moon and the tides, accelerating and retarding them at will, the same final results might be obtainable in a few hours of observation and measurement. This might be an advantage but is not, as we all know, a prerequisite to scientific study of these matters.

At this point, we should emphasize that the scientist observer, even in the instance of the moon and the tides, must control himself and his measurements even if he does not control the changes measured in the same sense of the word control. Haphazard observation and measurement will not suffice for scientific work. The precision of the measurements may be of a low order, but they must be systematic and correct within the degree of precision required in order to facilitate scientific inquiry. Usually, but not always, the more precise the measurements of change, the more soundly based are the ultimate warranted assertions.

Perhaps the most striking feature of modern scientific method is the development of experimental procedures. Controlled experiments are the scientists' means of facilitating their measurements of change. Specific examples may be more enlightening than generalized description.

The traditional man of science, at least to laymen, usually is the white-coated figure deeply engrossed in his laboratory experiment, probably peering into a test tube wherein he has the subject matter of his experiment well under control. Obviously this white-coated figure has a great advantage if, for example, we suppose he is measuring the oxidation of iron, over a scientist whose only means of making a comparable series of measurements is to observe and measure a piece of iron in his back yard as it slowly rusts away. By appropriate application of the heat from his bunsen burner and by other means the white-coated laboratorian, in a few minutes, can measure changes that his fellow scientist in the back yard cannot complete measuring for years.

Accompanying the development of the controlled experiment as a means of facilitating measurement of change and studying the relations among changes has been the development of special instruments devised to make such measurements more precise. For example, the 200-inch telescope at Palomar is the latest instrument in a series developed from the crude beginnings provided by Galileo and his predecessors. By means of such an instrument and various accessories such as the spectroscope, controlled measurements of changes among the celestial bodies can be made on a scope and with a degree of precision heretofore impossible. In this instance it will be noted that the observer and his measurements are controlled in the sense of being systematic and directed toward a definite objective. The celestial bodies are of course not under control in the same sense of the word that the laboratory scientist is said to control the materials in his test tube.

Two schools of thought have developed among those who have observed modern scientists at work. One group of such observers has been so preoccupied with the laboratory scientist's work with his materials in a test tube that they overemphasize the importance of such controlled experiments. They argue that controlled experiments (in this limited sense) are the essential feature of scientific method and that application of that method therefore is impossible or at best much more difficult with subject matter that cannot be put in a test tube in a laboratory.

Another group of observers has been similarly preoccupied with the instruments devised by scientists in order to facilitate their measurements of change and studies of relations among changes. Some members of this group argue that, until instruments of some unspecified type but comparable in complexity, precision, and purpose to the 200-inch telescope can be devised for use in work on social problems, there is no hope for success of the scientific method in studying human behavior.

Especially interesting is the fact that some of those who most strongly insist on the applicability of modern scientific method to all of man's problems at the same time discuss the subject of experiment in such a manner as to provide ammunition for the extreme experimentalists or instrumentalists mentioned above. Of course, the great advantage derived in some fields from laboratory experiment should not be belittled, nor should the marvelous intricacy and, to the layman, peculiar usefulness of modern scientific instruments be disregarded. But one should not forget that both laboratory experiments and the marvelous instruments that have been devised are but means to an immediate end, namely, the measurement of changes and study of the relations among changes. If that immediate end can be attained in any field by other means, we see no reason why the application of modern scientific methods of inquiry should not proceed.[6]

Lest misunderstanding arise, a few additional comments seem necessary. We do *not* imply that measurement of change and study of the relations among changes are the essence of scientific method, we assert only that they are necessary parts of such method. In the absence of the results of such measurements and studies as aids in the formulation of hypotheses and in the absence of such measurements in order to obtain the data that test hypotheses, a method of inquiry is neither modern nor scientific; a method of inquiry that did not include measurement of change and study of the relations among changes would, in effect, be a reversion to the pre-scientific procedures that have failed so dismally in man's history.

One other point should be made. We do not assert that progress in the sciences dealing with human behavior will be as rapid as it might be if a greater variety of controlled laboratory experiments were possible and better instruments were available. In due course a greater range of controlled experiments and many better instruments presumably will be devised. But we do assert that we have been unable to discover any other method of inquiry that even offers a hope of ultimate success in coping with the problems of men. Until a better method is devised, we assume that the best hope of progress lies in the method that has proved successful in greater or less degree whenever it has been applied to date.

Aspects of the New Method Applicable to Economics

ECONOMISTS ARE FORTUNATE in that measurement of change has long characterized their field. For example, price fluctuations are measurements

[6] As Dr. Ratner has pointed out, John Dewey never fell into the errors of either extreme school of experimentalists or instrumentalists. It is in large part to Dewey, of course, that we of Western Civilization owe our present understanding of scientific method and its general applicability.

of changing exchange ratios, and price data are available in great detail over long periods. Of course, the data become less voluminous and less reliable as one searches the records back 100, 200, or 300 years, but in recent decades and currently such measurements of change are widely available.

Measurements of changes in the output of manufacturies and farms also are available in great detail and for prolonged periods. In the United States the Census of Manufactures provides a wealth of historical data that are supplemented by more up-to-date measurements of change in great detail.

The changes in various other aspects of economic behavior also have been measured in detail over substantial periods. Changes in such items as employment, freight carloadings, purchasing media including bank credit, retail sales, investments, savings, and hundreds of others are reflected in reasonably accurate compilations of statistics that either directly or indirectly provide measurements of economic change.

Since World War I, measurement of economic change and study of the relations among such changes have been fostered by various research agencies of which the National Bureau of Economic Research is perhaps the outstanding example. On the whole, it appears that economists are in a far better position than their contemporary workers in the other social sciences and are far better off with reference to the availability of measurements of change than were all scientists when the other sciences were in a comparable stage of development.

Now the mere availability of measurements of change provides no assurance that the data are sufficient for the work that needs to be done, nor is there any assurance that the available data will be wisely used. Quite probably much more extensive measuring over longer periods and much more experience in using the results will be necessary in order that economic inquiries may progress as needed. However, there is no doubt that sufficient measures of change already are available for the testing of some economic theories or hypotheses. Even if the tests resulted only in discarding theories otherwise plausible and widely accepted, the data could be of great value.

Unfortunately, there is not yet widespread acceptance among economists of methodological standards. Older methods of inquiry still dominate the field in large part.

The urgent desirability of beginning with the crude macroscopic data of primary experience, rather than with the refined objects of reflection, is not generally recognized or at least is not insisted upon. That hypotheses should grow out of study (long and detailed study rather than cursory appraisal) of the changes that have been measured is not yet the accepted procedure.

Hypotheses have been developed in great profusion with elaborate extensions of intriguing theories. However, and aside from the semantic stumbling and logical inconsistencies found in many such theories, there is not as yet general insistence on control of theory by testing its logical implications against measured change. In the more advanced sciences, this is the standard procedure, and no scientist who wished to preserve his reputation would presume to suggest doing otherwise. In economics, some outstanding figures even deny that any possible experimental or experience tests could conceivably disprove their finely spun theories; and only a few seem to realize that a modern scientist does not pretend to have achieved warranted assertibility until such tests have been successfully met.

That the revolution in method fostered by Galileo has begun to be reflected in the field of economics has been apparent for some time. Thus far, however, progress has been slow. That the principles of modern scientific inquiry will be more widely applied in the field, that economists generally will eventually insist that the criteria for scientific work be met by those who claim to have achieved warranted assertibility is what we believe must take place if progress is to be assured.

Until that time comes, there is every indication that the persuasive proponents of popular panaceas will be accepted by the public as the economists who "know the answers." Whether policies adopted at their urging will prove to be one-way streets to disaster before better guidance can be derived from further scientific inquiry remains to be seen.

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> *The liberty of the individual must be thus far limited; he must not make himself a nuisance to other people. But if he refrains from molesting others in what concerns them, and merely acts according to his own inclination and judgment in things which concern himself, the same reasons which show that opinion should be free proved also that he should be allowed, without molestation, to carry his opinions into practice at his own cost.*
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> JOHN STUART MILL