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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ECONOMICS AS A SCIENCE.[1]

THAT economic and social studies should be carried on with the scientific method and spirit is not likely to be denied by any one here present. And yet there are persons who would have us believe that these important fields of investigation are by nature incapable of such a treatment. Even among economic students we find many writers of the type of Cliffe Leslie, who definitely disclaim that economics is a science, and class it rather as a branch of history. There has always been more or less hesitation as to the place economic studies should occupy as between the historical and scientific poles. The tendency to lean toward the historical side is indicated by the fact that the American Economic Association has regularly met in conjunction with the American Historical Association, while the tendency toward the scientific side is indicated by the fact that this section exists as a branch of the American Association for the Advancement of Science.

Those who maintain that economics is not and never can be a true science base their contention on the fact that social phenomena are not constant, 'like,' they say, 'the phenomena of astronomy or physics,' but differ widely at different times and under different circumstances. They point out that the determination of prices

[1] Address of the chairman of Section I of the American Association for the Advancement of Science, at the Ithaca meeting, July, 1906.

under modern free competition is quite different from their determination under the medieval system of custom and status; that the remuneration of labor depends on what are the historical and legal institutions with respect to slavery, labor legislation, etc.; that the economic phenomena of to-day are not comparable with those of the times of the Greeks and Romans, nor are the phenomena in America comparable with those in Russia.

To one who is familiar with the spirit of science, however, these variations, so far from being objections, are really confirmations of the theory that economics is a science. For in all science it is fundamentally true that phenomena will 'differ according to circumstances,' and the office of the scientist is simply and solely to find out under what circumstances one set of phenomena will occur, and under what circumstances another set will occur. We could hardly claim that hydrostatics is not a science for the reason that in a mountain lake water is found to be stationary and at a level, whereas at Niagara it is found to be in motion and passing from one level to another; that whereas the water in a mill-race passes in a downward direction, the water which we draw in our houses moves through the pipes upward; that whereas, by means of a syphon, water may be induced to flow out of a receptacle, it will, in an ordinary tub, remain inert. The whole science of hydrostatics has developed as a consequence of the persistent effort to unravel these puzzles, and to-day we know not only that under different circumstances water will act in different ways, but we can formulate what are the precise conditions under which it will act in each separate manner.

In economic study we should in like manner apply ourselves to discover what conditions make the difference in the phenomena between modern and ancient or eastern and western civilizations, rather than content ourselves with the truism that they do differ. Much of the field has in fact already been covered. It is known, for instance, that under conditions of free contract and competition, the price of an article will be determined by the intersection of its supply and demand curves, and that, on the other hand, if the régime be one of monopoly, the price will be determined on the principle of 'what the traffic will bear,' in the manner so admirably shown by Cournot. In these cases the results are not absolute and unconditional, but depend on specified hypotheses. In this respect they are exactly similar to any other scientific result. The formula of science, as Newcomb points out, is always conditional—if A is true, then B is true. The formula of history, on the other hand, is unconditional—simply B is true.

If economics is a science, its truths must be conditional. Thus, the incidence of a tax on ground rent will lower the value of land, *provided* there are no counteracting causes. This does not assert that actually, after such a tax, the value of the land will fall, for in the meantime some opposing cause may have intervened, such as the discovery of an oil-well. Again, an increase of the quantity of circulating medium will raise prices proportionately, provided the velocity of circulation and the volume of business transactions remain the same. This 'quantity theory' does not assert that prices *do* rise after every increase in the quantity of money, and those who thus interpret it are guilty of the confusion already noted between conditional and unconditional truth—in other words, between a scientific law and a historical fact.

The confusion between historical and scientific truth is very common among economists, especially in the German historical school. While Roscher and his followers verbally classify economics as a sci-

ence, they leave no place for economic *theory*. Curiously enough, they imagine that by confining themselves to historical generalizations they are following the inductive method of Bacon. A closer study of Bacon's work would have revealed to them that true science does not consist in the mere grouping of historical phenomena. In fact, Bacon makes a distinction between what he calls the popular and the inductive method, or what may be preferably called, following the example of John Rae, the *systematic* and the *scientific*. The two are commonly confused, but are entirely distinct. 'System' consists in classifying phenomena; 'science' consists in discovering the laws to which they conform. System explains phenomena by means of what is common and familiar; science explains them by what is simple, however recondite. System is exemplified in such descriptive studies as grammar, descriptive geography and history; science is exemplified by such analytical studies as mathematics, physics, and latterly, biology. The classifier or system-maker is content with generalization of facts. These express the *usual* order of events, for instance, that the sun rises once a day. They do not express the reason or principle. The difference between system and science is the difference between a general fact and a necessary truth, between *rules* and *laws*. Exceptions to rules do not destroy them as rules; in fact, we say 'the exception *proves* the rule.' This, however, is not true of laws. A 'law' which has an exception is no law at all.

Many studies which are now scientific had their origin in what was originally systematic. The predecessors of the modern physicists classified bodies into 'light' and 'heavy.' Iron, they maintained, is heavy and therefore falls; fire is not heavy, and therefore rises. How different is this obsolete method of treating the subject from our modern analytic notion of gravity, or rate of increase of velocity, by means of which are explained both the falling of iron and the rising of 'fire.'

Similarly, the prototype of biology was 'natural history,' and consisted chiefly in the mere classification of animals and plants into species, genera, etc. Modern biology has supplanted such elaborate classification by introducing, through Darwin, the analytical ideas of heredity, variation and selection, and in this way the descriptive study of natural history has been converted into the true science of biology.

The same evolution which has been outlined in physical and biological science is doubtless taking place in economic science. Yet it must be confessed that few have yet mastered the distinction between a general fact and a scientific law. When we hear it stated as fundamental in political economy that skilled labor is better paid than unskilled, it is clear that this is merely a general rule and not a necessary law. The single fact that certain seamstresses, though skilled, are illpaid, is sufficient to disprove the statement as a necessary law, though it does not affect it as a general fact.

The historical school justly complains of the superficial character of the theories which have been sometimes offered. This objection holds, however, not against theory as such, but against *false* theories; and herein lies the virtue of Bacon's method. The inductive method, by which any theory of phenomena must be checked by reference to actual historical fact, thus forms the means of distinguishing between truth and falsity. Rejecting false theories is quite different from rejecting all theories. What is needed now in political economy is to rid ourselves of the false and superficial theories, on the one hand, which have been constructed *a priori* and irrespective of facts; and, on the other

hand, to release ourselves from the cheap empiricism of the historical school, who interpret their task as merely one of generalizing phenomena without analyzing them. In the words of the great philosopher, Hume, 'Our speculations can scarce ever be too fine, provided they be just.'

Science is one. The logic for economic science should be the logic for all science—a combination of induction and deduction. Facts are at once the test and the material of science, but laws are its ultimate goal. Laws are not facts, but the relations between facts. Newton's first law of motion, that a body tends to move uniformly in a straight line, is not a fact, nor is it a general expression of facts. Probably no particle in the universe has ever moved exactly in a straight line or with uniform velocity for so much as a single second. Yet it would be an error to conclude that Newton's law is unreal and untrue in actual nature. The law has an 'if' in it—'*if* a body were acted on by no force, or by perfectly balanced forces, its motion *would* be uniform in both rate and direction.' Withdrawn thus from actual events, Newton's law seems to the non-scientific mind to lose all objective truth. This again is an error. Newton's law is absolutely true to nature. The fact that it is conditional does not make it arbitrary. We are not free to replace it by the medieval opinion, viz., 'If a body is let alone it will gradually spend its force and slacken its speed.' This formulation, unlike Newton's law, would not stand the test of facts. A valid law is true at all times and places, in the sense that should the particular conditions arise, the prescribed result would follow, but not in the sense that the particular conditions must needs ever arise.

When the relations between scientific and historical truth are more fully realized, we may expect economic studies to make more rapid strides than have hitherto been possible. We shall recognize the two-fold nature of most practical economic problems, such as the present problems of trades-unions, insurance, railroad rate regulation and the tariff. These problems require first of all the study of historical facts, and secondly, the discovery of the relations to which these facts conform. When these two studies are complete we are prepared to take a third and final step, *prediction*. It is sometimes said that the ability to predict is the final test of science. But it is not a test of science only. Successful prediction requires two conditions: one is a knowledge of science—of what will happen under given circumstances; and the other, equally essential, is a knowledge of history—of the particular circumstances of the present moment, out of which the future, to be predicted, will grow. Failures of prediction are due to the lack of either of these two essential conditions.

An example of a failure of prediction due to imperfect knowledge of facts is found in the case of the closure of the Indian mints to silver in 1893. It was expected that the value of the silver rupee would be maintained at 16 pence. But no account was taken of the large coined hoards of silver among the natives. After these had been put into circulation the price of the rupee did eventually rise to 16 pence and has remained there ever since. In this case the failure of prediction at first was due, not to any defect in monetary *science*, but to ignorance of Indian *history*.

Usually, however, failures in economic prediction are due to the lack of scientific rather than of historical knowledge. In the civil war, when there was a premium on gold, the scientific explanation of which was really simple, the public attributed the premium to the machinations of speculators. Accordingly, Congress was induced to close the Gold Exchange, whereupon,

to the consternation of the framers of this foolish prohibition, the premium on gold soared higher than ever. The result was a hasty and shamefaced repeal.

Experience of this kind is too common in economic legislation. It serves as a warning that we should know something of economic science before venturing to tamper with economic conditions. The men who need this warning most of all are those who despise all 'theories' and call themselves 'practical.' It is they who legislate a measure one day and have to repeal it the next. A *truly* practical man can predict how a measure will work, and his power so to do requires not only what is called 'practical' but also what is called 'theoretical' knowledge; a knowledge, in short, not only of *history* but of *science*.

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SECTION D—MECHANICAL SCIENCE AND ENGINEERING.

THE meetings of the section were held in the lecture room of Sibley College of Mechanical Engineering and Mechanic Arts, of Cornell University, on Friday and Saturday, June 29 and 30. They were followed by the fourteenth annual meeting of the Society for the Promotion of Engineering Education, an affiliated society of the association.

In the absence of the vice-president, the retiring vice-president, Fred W. McNair, president of the Michigan College of Mines, acted as chairman of the section. Twenty-three members of the association registered as belonging to the section, while members of other sections attended some of the meetings. Experience gained at this meeting has shown that it is not conducive to the greatest attendance to have Sunday intervene between the meetings of the section and of the affiliated society.

The first two papers were by Byron B. Brackett, professor of physics and electrical engineering of the Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y. The first paper describes a 'Lamp Bank composed of Small Separate Units.' Each unit consists of twelve incandescent lamps arranged in a partially open box, 28 inches long and 10 inches square. The boxes are open enough to give perfect ventilation. On one side are placed switches for cutting in or out the lamps of that particular box, and for changing the grouping of the lamps into parallel, series or combination arrangements. As many of these units as are desired may be placed one upon the other in tiers, and as many tiers as are needed may be placed side by side to form a lamp bank of any capacity. Each unit is constructed to permit convenient interconnection with the adjacent ones. Thus, the large bank may be separated into smaller ones whenever desired and reassembled with the least possible loss of time and effort for special tests on large machines.

His second paper was on an 'Alternating Current Wave-form Apparatus.'

To set the armature accurately for the separate readings in the ballistic method of tracing the E.M.F. wave of an alternator, a double or duplicate brake apparatus is unusually satisfactory. Two similar clamp brakes with long arms are placed on the pulley side by side. With the arms held rigidly the desired readings for one observation are made. Then brake No. 1 is unclamped at the pulley, the end of its arm released and rotated up a short distance to a fixed stop. Brake No. 1 is now clamped to the pulley, brake No. 2 is unclamped, the end of No. 1 turned down to its original position and No. 2 is clamped again. Thus the armature has been rotated through a small angle, that may be computed with great accuracy from the length of the arms and the distance