1961

# Jurimetrics: Science and Prediction in the Field of Law

Lee Loevinger

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*The twentieth century has seen the most spectacular advances in the achievements of science and its products, as well as in the proliferation of legal rules and precedents. In this Article, Mr. Loevinger discusses the role that science has played, and is likely to play, in the field of law. He points up the great potentialities which science has to offer to the lawyer such as electronics in the field of data retrieval. He concludes that the lawyer will have to adapt himself to the evolving and emerging miracles of man's newest intellectual achievements if the legal profession is to retain its position of intellectual leadership in this country.*

Lee Loevinger*

Science and law have been linked in man's speech and thinking for centuries. Indeed, it was quite common for writers of an earlier era to refer to what they called the "science of law." However, it may be safely assumed today that anyone who uses such a phrase seriously does not understand science, whatever he may know of law. Consideration of the present relationship between law and science must begin with the recognition that modern science and contemporary law are separate disciplines which, so far, have had relatively little influence on one another.

Science, in one sense at least, is as old as the self-conscious human mind. Whenever man has been engaged in the investigation of phenomena by observation, measurement and experimentation, there has been scientific activity. However, science as a separate and self-conscious discipline is a relatively recent development in man's history. James Conant has observed that:

> As one skims the histories of the natural sciences, it seems clear that in the embryonic stages of each of the modern disciplines, violent polemics rather than reasoned opinions often flowed most easily from the pen. . . . But if I read the history of science in the Seventeenth and Eighteenth centuries rightly, it was only gradually that

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there evolved the idea that a scientific investigator must impose on himself a rigorous self-discipline the moment he enters his laboratory.[1]

By the end of the nineteenth century, the intellectual movement which began slowly in the sixteenth and seventeenth centuries with Copernicus, Vesalius and Galileo had developed into a self-conscious and integrated discipline calling itself science. It had produced a substantial body of learning and laid the foundations for most of the advances in this field that have occurred since then. The power and achievements of science had by then become so impressive that they seemed to promise a method of solving all problems, social and legal, as well as those arising out of the physical environment.

The great scientist Karl Pearson, writing in 1892, expressed the spirit of his age when he said:

The classification of facts and the formation of absolute judgments upon the basis of this classification—judgments independent of the idiosyncracies of the individual mind—essentially sum up the *aim and method of modern science*. The scientific man has above all things to strive at self-elimination in his judgments, to provide an argument which is as true for each individual mind as for his own. *The classification of facts, the recognition of their sequence and relative significance is the function of science*, and the habit of forming a judgment upon these facts unbiased by personal feeling is characteristic of what may be termed the scientific frame of mind. The scientific method of examining facts is not peculiar to one class of phenomena and to one class of workers; it is applicable to social, as well as to physical problems, and we must carefully guard ourselves against supposing that the scientific frame of mind is a peculiarity of the professional scientist.[2]

The same views were expressed by the great lawyer and jurist, Oliver Wendell Holmes, speaking as early as 1895 when he said: "An ideal system of law should draw its postulates and its legislative justification from science. As it is now, we rely upon tradition, or vague sentiment, or the fact that we never thought of any other way of doing things, as our only warrant for rules which we enforce with as much confidence as if they embodied revealed wisdom."[3]

Holmes reiterated this theme more than once; and he spoke for a school and a generation of legal realists when he declared: "For the rational study of the law the black-letter man may be the

1. CONANT, ON UNDERSTANDING SCIENCE 6–7 (1947).
2. PEARSON, THE GRAMMAR OF SCIENCE 6–7 (1st ed. 1892).
3. HOLMES, *Learning and Science*, in COLLECTED LEGAL PAPERS 139 (1920).

man of the present, but the man of the future is the man of statistics and the master of economics."[4]

Holmes restated this theme when he said:

> The growth of education is an increase in the knowledge of measure. To use words familiar to logic and to science, it is a substitution of quantitative for qualitative judgments. . . . [I]n the law we only occasionally can reach an absolutely final and quantitative determination, because the worth of the competing social ends which respectively solicit a judgment for the plaintiff or the defendant cannot be reduced to number and accurately fixed. The worth, that is, the intensity of the competing desires, varies with the varying ideals of the time, and, if the desires were constant, we could not get beyond a relative decision that one was greater and one was less. But it is of the essence of improvement that we should be as accurate as we can. . . .
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> I have tried to show by examples something of the interest of science as applied to the law, and to point out some possible improvement in our way of approaching practical questions in the same sphere. To the latter attempt, no doubt, many will hardly be ready to yield me their assent. But in that event, as in the other, I have had in mind an ultimate dependence upon science because it is finally for science to determine, so far as it can, the relative worth of our different social ends, and, as I have tried to hint, it is our estimate of the proportion between these, now often blind and unconscious, that leads us to insist upon and to enlarge the sphere of one principle and to allow another gradually to dwindle into atrophy. Very likely it may be that with all the help that statistics and every modern appliance can bring us there never will be a commonwealth in which science is everywhere supreme. But it is an ideal, and without ideals what is life worth?[5]

The twentieth century has seen the most spectacular advances in the achievements of science and its products, as well as in the proliferation of legal rules and precedents. If then the foresight of those who spoke for the nineteenth century was sound, it would be reasonable to expect that science should by now have made at least some substantial contributions to the solution of basic legal problems. However, realism compels the conclusion that science has contributed little, if anything, to the solution of social or legal problems. Indeed, it may well have exacerbated latent problems or even created new ones.

This immediately poses a challenge to seek the reason for this failure. Has science failed to live up to its promise? Have we failed to recognize or utilize the answers provided by science? Or was the insight of earlier thinkers in error, and is science necessarily

4. HOLMES, *The Path of the Law*, in COLLECTED LEGAL PAPERS 187 (1920).

5. HOLMES, *Law in Science and Science in Law*, in COLLECTED LEGAL PAPERS 231, 242 (1920).

concerned only with physical phenomena, and inapplicable to social fields?

It seems to me that we cannot yet give an unqualified answer to any of these questions. However, part of the difficulty quite obviously stems from the fact that we have asked science the wrong questions, and set it at the wrong tasks. We have expected science to distill social policies from a test tube or a retort, much as Aladdin summoned a genie by rubbing a magic lamp. We have imagined that social scientists could produce tables that would permit us to read the numerical value of competing interests and desires much as the mathematicians have produced for us tables of logarithms, sines and cosines. With the recent advent of electronic computers, some people now have the impression that we may be able to produce or construct a machine that will give the answers to legal questions, or at least give us reasonably accurate predictions as to the judicial decision of legal issues. All of these expectations seem unfounded and equally doomed to frustration.

It must be recognized that the term "science" is itself ambiguous and no more easily defined than is the term "law."[6] "Science" may refer, variously, to accumulated bodies of knowledge on specific subjects, to the material products of these bodies of knowledge, to the bodies of professionals who are engaged in research in specific fields, to specific techniques of research employed by such professional scientists, or to certain common characteristics of methodology and conceptualization which are thought to typify the activities of scientists. It is not important that we should seek or find some particular definitive meaning for "science." What is important is that we should be able to examine fields in which human knowledge and power have been successfully increased and to borrow from such fields so much as may be adaptable to our legal and social problems.

When we examine the fields of science from this viewpoint, it becomes apparent that there are at least two great categories of work and achievement. In the current jargon, these are known as the fields of "hardware" and "software." "Hardware" means simply the mechanical devices—the physical machines—that science has produced. "Software" means the intellectual systems of designs and concepts that have been produced. Science offers us both mechanical and intellectual tools. But we must recognize that it offers us nothing more than tools. Science has produced many marvels for recording, reproducing and transmitting language. We have dictating and transcribing machines, electric typewriters, tele-

6. Loevinger, *Jurimetrics*, 33 MINN. L. REV. 455 (1949).

typewriters and radio telephones. However, science has not produced and does not yet promise to produce a mechanical secretary, much less an author.

It is often said that science has transformed our lives. It is necessary only to mention the machines that have been developed in order to realize how fundamentally our living has been changed. Think of the printing press, the railroad, the automobile, the airplane, electric generators and lights, the telegraph, the telephone, radio, television and, perhaps, most momentous of all, the atomic bomb.

However, it is not really the fact that these things have changed our way of living. This is merely a figure of speech. In truth what has happened is that we have changed our own lives in adaptation to these machines, and their opportunities, their promises, and their threats. It is neither reasonable nor realistic to expect the invention of a machine that will do for us, only more rapidly and with less human effort, the same thing that we have been doing inefficiently for ourselves. Rather, what science offers us is tools that will permit the same things to be done in a new way or things to be done that could not have been attempted previously.

However, the utilization of both the mechanical and the intellectual tools of science requires the adaptive effort of those who have tasks to be performed. The applications of science to human affairs are not self-executing. They require the activity and the effort of those who would secure the benefits—or detriments—of the results. Instruments of communication are mute until man gives them words. Means of transportation are stationary until man guides them to their destination. Instruments of observation are useless until man employs the telescope to search the outer reaches of the cosmos, or the miscroscope to examine the inner crevices of the microcosmos.

Before we can employ any of the tools of science, we must first understand them. Therefore, I suggest that the most promising avenue of legal progress in the contemporary world is the path of jurimetrics. This is the study of law and legal problems by scientific methods and concepts, the employment of science in law to the extent that it is applicable or adaptable.

The most useful and significant tools that science now offers to law are intellectual rather than mechanical. These tools are numerous, complex and subtle and, taken together, involve a range of technical detail which probably exceeds the comprehension of any single mind. However, there are certain basic concepts of science which are of sufficient generality and significance to be both comprehensible and important to all those concerned with the intellectual foundations of any contemporary discipline. The first and perhaps the most important of the basic concepts of science is that of having realistic criteria of meaning. As Hans Reichenbach puts it: "Statements about reality have sense only if they can be translated into statements about real things; the reference of the events in the world to ideal entities of ghostly character, like an absolute time moving along of itself, or an absolute space, is avoided on principle."[7]

Of course, scientific reality is not confined to tangible things. Science deals also with abstract concepts. However, these too must meet the criterion of realism. P. W. Bridgman, in a now classic statement, has said:

> In general, we mean by any concept nothing more than a set of operations; *the concept is synonymous with the corresponding set of operations.* If the concept is physical, as of length, the operations are actual physical operations, namely, those by which length is measured; or if the concept is mental, as of mathematical continuity, the operations are mental operations, namely those by which we determine whether a given aggregate of magnitudes is continuous. . . . [A] consequence of the operational character of our concepts . . . is that it is quite possible, nay even disquietingly easy, to invent expressions or to ask questions that are meaningless. It constitutes a great advance in our critical attitude toward nature to realize that a great many of the questions that we uncritically ask are without meaning. If a specific question has meaning, it must be possible to find operations by which an answer may be given to it. . . . I believe that many of the questions asked about social and philosophical subjects will be found to be meaningless when examined from the point of view of operations. It would doubtless conduce greatly to clarity of thought if the operational mode of thinking were adopted in all fields of inquiry as well as in the physical. Just as in the physical domain, so in other domains, one is making a significant statement about his subject in stating that a certain question is meaningless.[8]

Thus, in any scientific view, a meaningful statement must be one the truth and falsity of which entail different consequences that are subject—at least in principle—to objective investigation.

A second basic concept of the scientific view is that of quantification, the varieties of quantification, and the limits set to it by the pervasive fact of indeterminacy. It is generally recognized that science deals largely with numerical descriptions of phenomena. However, it is not so generally understood that numbers may have different meanings depending upon the manner in which they are

7. REICHENBACH, ATOM AND COSMOS 54 (1932).
8. BRIDGMAN, THE LOGIC OF MODERN PHYSICS 5, 28–30 (1927).

used. Ordinarily numbers are used to indicate measurement on an interval scale. In the most obvious example, we measure space by inches, meters or some other similar convenient unit. Although not so simply measured, such things as time, weight, volume, speed and temperature are also measured on interval scales. The differences between points on such scales separated by the same number of units is the same regardless of the position of these points on the scale. Thus, the distance between the one inch and the two inch mark on a foot rule is just the same as the distance from the 11 inch to the 12 inch mark.

In contrast, we may also use scales that are similarly marked off in numbers but on which the numbers indicate only the order of occurrence and have no other quantitative significance. Perhaps the most elegant example of this is a beauty contest in which a number of superlatively attractive females may be rated as Number 1, Number 2, Number 3, and so forth, without any insinuation that the differences in their pulchritudinous merits are measurable other than by such a rank-order arrangement. This is an ordinal scale. Such scales are used for measurements of skill, performance and intangible qualities such as intelligence. A very simple ordinal scale is used conventionally in the law for measuring the quantum of evidence. Thus, in every lawsuit tried on factual issues, the court must reach a determination that one side or the other has presented the greater quantum of evidence, although no other quantitative measure of the evidence is attempted.

A third type of scale, used for some special types of measurement, is a ratio scale. The most common example of this is the ordinary slide rule. An example of a practical application of the ratio scale may be found in the logarithmic papers that are sometimes used for computing investment profits. To give a simple illustration: if a security costing $2.00 increases two points in price, going up to $4.00, the investor has doubled his investment. On the other hand, if a security costing $100 goes up two points in price to $102, the investor has made only two per cent profit on his investment; and his security will have to increase 98 more points to give him double his original investment.

The most important practical distinction to be noted here for law is that between cardinal and ordinal numeration. When a number is used to indicate the results of measurement on an interval scale, as when height, weight, time or speed are indicated, it has an altogether different significance than when it is used to indicate position on an ordinal scale.

Another fact which frequently escapes notice in view of the fantastic precision of which science is becoming capable in many fields is that all measurements and quantitative determinations are only approximate. Many measurements can be made with a degree of precision that far exceeds any practical need or application. Nevertheless, it remains true that there is an inescapable degree of indeterminacy in all of our quantitative measurements. Furthermore, P. W. Bridgman adds,

> [A]ll experience seems to be of this character; we never have perfectly clean-cut knowledge of anything, but all our experience is surrounded by a twilight zone, a penumbra of uncertainty, into which we have not yet penetrated. . . . It is a general consequence of the approximate character of all measurement that no empirical science can ever make exact statements. This was fairly obvious in the case of mechanics, but it required a Gauss to convince us that the geometry in which we are interested as physicists is an empirical subject, and that one cannot say that actual space is Euclidean, but only that actual space approaches to ideal Euclidean space within a certain degree of approximation.[9]

So, while the data of science are commonly expressed in mathematical, frequently numerical, terms, they also commonly carry their own indicia of indeterminacy. In order to understand this language of science it is necessary to have at least some knowledge of the elements of mathematics. The range of this subject is far too great, and its nature too complex and profound, for cursory discussion. It may, however, be pertinent to note that mathematics is a language of extraordinary subtlety and expressiveness for the statement of exceedingly general abstract concepts. As a language, it has its own rules of grammar, syntax and internal operation. It is not in itself an empirical discipline; but it has become the indispensable means by which we are able to test the consistency of hypotheses with bodies of empirical data and with systems of concepts, and to spin out the implications and consequences of hypotheses.

The branch of mathematics that appears to be of the most immediate practical utility in the fields of law and the behavioral sciences is statistics. There is much in statistics that is of present practical application in day-to-day legal problems and it has good claim to be included in every law school curriculum.

The two conditions for the use of statistical methods are (1) that we be dealing with numerical data, and (2) that we be dealing with a universe of which we have either a complete census or a representative sample. A valid sample of a universe requires that there be either a completely random selection or that there

9. *Id.* at 33–34.

be a purposively structured selection. In either case, the number in the sample must be sufficiently large to insure that the sample is representative of the universe in view of its mode of selection. There are statistical techniques for determining the validity of selection of a sample from a given universe.

The character of a universe can be determined from a valid sample by statistical measures of central tendency and dispersion. The most commonly used and understood measure of central tendency is the average or the arithmetic mean. However, this is frequently a very misleading index. There are many situations in which it is more valid to use some other measure such as the median, or the midpoint of the range, or the mode, which is the most frequently occurring measure in the distribution. There are other measures of central tendency, but these are of greater technical complexity and more specialized use.

The range of distribution is the simplest and most commonly used measure of dispersion. However, like the arithmetic mean, it is sometimes a misleading index. More significant measures may be the standard deviation, which is the range that encompasses two thirds of all the cases, or the mean deviation, which is the average of deviations of the items in a distribution from their arithmetic mean. There are also several other measures of dispersion which are of varying complexity and adapted to use in a variety of situations.

One of the most important uses of statistics is the determination and expression of degrees of correlation. Correlation is a measure of the relationship between two sets of values; as, for example, between height and weight. It is commonly expressed on a unitary numerical scale, on which zero indicates that the two values occur independently of each other, lacking any correlation, and 1 indicates that there is perfect correlation, so that a value in either set will indicate the magnitude of a corresponding value in the other set.

Correlation is closely related in logical analysis to the concepts of causation and probability. Without becoming mired in the philosophical and legal quagmire of causation, it may be noted that there is some ground for supposing that the most satisfactory view of causation is to regard it as a limiting case of correlation.[10] In any event, whether regarded as analytically separate or related concepts, from a scientific viewpoint both correlation

10. See Dellwo v. Pearson, 259 Minn. 452, 107 N.W.2d 859 (1961), and references cited in footnote 3 thereof.

and causation are inseparably based upon some notion of probability.

One of the most fundamental, ubiquitous and useful conceptual tools of modern science is the concept of probability. Indeed, it is doubtful if one may pursue any contemporary inquiry beyond a relatively superficial level without encountering or employing some use of probability. On the other hand, despite the earnest inquiry and often profound thought that has been given to the issue for more than a century, there is not yet any single meaning that is universally regarded as definitive of this concept. There are however, a number of views of the probability concept which may indicate that it is used with some variety of meanings.

The most widely accepted scientific view of probability is a refinement of the classical formulation of Laplace, who defined probability as the quotient obtained by dividing the number of favorable cases by the number of equally possible cases.[11] The frequency definition of probability avoids the reflexive character of the classical definition inherent in the use of the term equal possibility. The frequency definition of probability, sometimes called the von Mises-Reichenbach definition, states that probability is the frequency with which an event of a specified kind belonging to a category of events occurs within a sequence of events of that category.[12] For example, the probability of a coin coming up heads or tails is defined as the relative number of times that the coin comes up heads or tails in a series of events in which the coin is tossed so that it may come up either heads or tails. By this view, probability statements are objective, but they are meaningful only if we can give a frequency interpretation of them, which requires that all events as to which such a statement is made must be instances of a class of similar events.

The obvious limitations of the frequency concept have led to attempts to formulate alternative theories of probability. In sharpest contrast to the objective definition is the subjective definition, which states probability to be merely an expression of the degree of confidence or doubt with which an assertion is made. The difficulty of attaching any numerical value to a subjective feeling, as well as the other obvious objections to it as a term in public discourse, have prevented this theory from securing much adherence among logicians or scientists. Nevertheless, we must recognize that this is the popular sense in which the term is most fre-

11. SIMON, MARQUIS DE LAPLACE, A PHILOSOPHICAL ESSAY ON PROBABILITIES (1795).

12. MISES, PROBABILITY, STATISTICS AND TRUTH (1928); REICHENBACH, EXPERIENCE AND PREDICTION (1938).

quently used, and as such has considerable currency regardless of logical justification.

The most sophisticated alternative to the objective theory of probability is the logical proximity theory suggested by J. M. Keynes[13] and developed most recently by Rudolph Carnap.[14] By this view, probability is a special kind of logical relation between two statements. The extreme cases are those of derivability and contradiction. Between these limiting extremes, probability represents the degree of confirmation of the conclusion on the basis of the evidence which we take as the premise. Carnap declares that this concept is the foundation of all inductive reasoning, and has undertaken to formulate what he claims to be a quantitative system of inductive logic, or a means for specifying the degree of probability of the conclusion from nonquantitative evidence. I confess to some difficulty with these efforts to quantify inference on the basis of nonquantitative algebra, and find the proposal somewhat more pretentious than productive. Nevertheless, there is at least a promise of plausibility in this theory, and it may be of significance to those who work in an area in which the frequency theory inevitably encounters great difficulty.

A fourth major alternative view of probability seeks to combine the elements of the frequency and the logical proximity definitions. This is the truth-frequency theory, which is the suggestion of C. S. Peirce.[15] The truth-frequency theory states that probability is the frequency with which a proposition of a specified class is true if there is as much evidence for it as there is for other propositions of that class. For example, suppose we take as the class those judgments that have been established by proof "beyond a reasonable doubt" (whatever that may mean). Let us further suppose that we have established by past investigations that out of 100 cases in which such a quantum of evidence has supported the judgment, the judgment has been found to be true in 99 cases. It then follows that the probability of a judgment being true, if it belongs to the class of judgments supported by evidence beyond a reasonable doubt, is .99. Conversely, of course, this also means a probability that out of every 100 such judgments, one will be false. The difficulty with this definition obviously is that it too may be reflexive, in that most of the propositions for which we seek to give such a probability value have nothing in common except the probability value assigned. But the difficulty is not theoretically inescapable and this is at least a potentially useful view of probability.

13. KEYNES, A TREATISE ON PROBABILITY (1921).
14. CARNAP, LOGICAL FOUNDATION OF PROBABILITY (1950).
15. PEIRCE, CHANCE, LOVE AND LOGIC (1923).

Although it has generally escaped the notice of nonscientists, all scientific conclusions are probability statements. Science reaches no judgments or conclusions, and makes no predictions, except in terms of probability. As Karl Popper has pointed out, since the dimension of all probability statements is infinite, no experimental results, however numerous or favorable, can firmly establish a relative frequency.[16] In principle, therefore, probability statements are neither strictly falsifiable nor verifiable and do not rule out anything observable. However, as a practical matter, probability statements may be utilized methodologically as if they were empirically falsifiable and verifiable, and they are subject to varying degrees of corroboration. The significance of this differentiation between proof and corroboration is that empirical statements never become fixed or absolute beyond further challenge or investigation. Thus, science remains an open system on both the theoretical and the practical level.

It is this characteristic which has accounted for most of the scientific progress of the twentieth century. The new theories of physical science have neither falsified nor supplanted classical principles. Rather, they have shown that the classical principles are not universal but valid only within limited spheres. The principles of relativity and quantum physics are applicable in areas beyond those to which Newtonian mechanics can be applied; and it seems likely that if man continues his quest for understanding, he may develop theories and principles that go beyond any of those now known.

In science, as in law, the most practical applications of principles are those which enable us to make predictions. In this connection, it is indispensable to note that the techniques of prediction are the same as the techniques of analysis, which have been summarily reviewed in the foregoing discussion. Analysis is nothing more than the process of prediction applied to past events, or what one may call postdiction. Prediction, on the other hand, involves interpolation or extrapolation from an analysis. There is no objective way of validating an analysis except by extending it to an unknown case by prediction or postdiction and then determining the degree to which observation corroborates it. Thus, regardless of its character, any valid analysis can be utilized for purposes of prediction; and there can be no such thing as prediction except as it is based upon an analysis of the phenomena involved. Furthermore, every prediction with any pretension to scientific validity or foundation, is simply a probability statement.

16. Popper, The Logic of Scientific Discovery 189 (1959).

This raises the problem that has caused almost as much difficulty as the definition of probability itself. The problem is: what is the meaning of probability as applied to the instance of a single case? It is the general view that the frequency theory of probability is simply inapplicable to the instance of the single case. This is not, as sometimes assumed, because the single case is unique or because it is not capable of replication. Uniqueness is simply a matter of degree and is not a categorical distinction of any case with which we deal. Every case is unique in some aspect; but no case that we are capable of considering or discussing is wholly unique, or we would have no means of either conceiving or discussing it. Neither is the impossibility of replication the objection to application of frequency probability to the single case. A frequency probability judgment is as inapplicable to the single toss of a coin as it is to the prediction of a single lawsuit. Obviously, the toss of a coin can be replicated; and, indeed, coin tossing as a class of events is the classic example of frequency probability. The difficulty has been that it is impossible to give a rigorously logical meaning to a frequency probability prediction about a single event, such as the toss of a coin or an individual lawsuit.

It seems to me that this logical dilemma suggests that the term probability may be used in different senses in different situations. From the operational viewpoint, probability obviously means the operations by which we derive a particular probability value. Ordinarily, these will be the observation and counting of past cases. However, when we are seeking to predict the results of a single future case, what we are apparently attempting to invoke is a degree of confidence as a basis for action. In any event, we can and do rely upon probability judgments in predicting the outcome of single cases, and such reliance is justified by the criterion of success. It may well be that we can convert a probability statement derived from the frequency of occurrence of past events to a probability statement applicable to future events with a truth-frequency significance. This would avoid the theoretical difficulty of applying a probability judgment to a unique case by synthesizing a category for every case. Each case, regardless of its other characteristics, would then belong to the category of other cases having an equal probability value.

When we seek to apply these principles to the problems of legal prediction, a few more observations must be made. To begin with, we must recognize that legal prediction is an activity in which lawyers, and for that matter citizens in all occupations, are commonly engaged. The effort is obviously not uniformly successful and there are inconsistencies and failures both for lawyers and for citizens in every variety of situation. Nevertheless, there are also notable successes and, as Karl Llewellyn has recently pointed out, the common law tradition supplies a good many elements of stability to the framework within which legal prediction is ordinarily made.[17] The question, therefore, becomes whether the data and methods of science can add anything substantial to the art of legal prediction as presently known and practiced by those learned in the law.

It should be noted that the function of legal prediction normally takes the facts of the case as premises which are given, and considers only the problem of determining law in such a context. Of course, this is a great oversimplification of the actual problem. The determination of facts in a case is ordinarily the controlling function. It is frequently true that a relatively small difference in finding or viewing the facts will be the determinative point in the application of differing legal principles. Much, and perhaps most, of the uncertainty in legal prediction arises from the inability to forecast what the facts will be, or what the courts will infer them to be from the evidence, or even what the evidence will be upon trial. Further, it must be kept in mind that the courts never know the facts of any case, and lawyers seldom do. Courts and lawyers alike are ordinarily limited to a knowledge of the evidence which is, at best, a partial and not altogether accurate indication of what the facts are.[18]

The issues of fact determination are still empirical problems which are essentially the same as those with which science deals in other fields. In the area of fact determination, the law has already adopted many of the techniques and data of science. Modern crime detection services, such as the FBI, utilize highly developed scientific laboratories in which all of the physical and biological sciences are employed in the detection of crime and the identification of criminals. Medical science is, of course, employed extensively and habitually by the law in matters involving personal injury and similar factual issues. The physical sciences are also employed in the testing and identification of questioned documents. The physical sciences are utilized, both practically and theoretically, in determining such matters as the speed of vehicles, braking distances and the force and direction of impact in collisions. Science has been less successful in developing techniques for testing the

17. LLEWELLYN, THE COMMON LAW TRADITION: DECIDING APPEALS (1960).

18. Loevinger, *Facts, Evidence and Legal Proof,* 9 W. RES. L. REV. 154 (1958), reprinted in HENSON, LANDMARKS OF LAW 422 (1960).

truthfulness and reliability of testimony, and the law has been much more skeptical of the techniques that have been developed. Nevertheless, a significant amount of work has been done in the field of the detection of testimonial deception, and the establishment of legally acceptable techniques in this field appears to be only a matter of time. Considerably less has been done in the field of developing methods of testing testimonial reliability. This appears to be a problem which should challenge both the legal scholar and the psychologist, and it may be hoped that their joint effort will produce some useful results within the next few years. In addition to the reliance upon numerous scientific techniques, the law has made great strides in its own procedure for fact determination, principally in the numerous devices for pretrial discovery of evidence. All of these together have, to some extent, made determination of the evidence in a case much more predictable.

But, despite the adoption of all these devices, it still remains true that the determination of facts is the greatest single element of uncertainty in the overwhelming majority of cases. In those situations in which prediction is attempted while the facts are still wholly or partially prospective the difficulty is that the facts which actually develop may not correspond altogether with those that were postulated; and, even if they do, the evidence finally adduced in court may not indicate this to the judge or jury. Where the facts are already matters of history, there are most commonly great differences in the views taken of them by different parties, and evidence is notoriously unpredictable.

The one point that is inescapable is that some method of legal prediction is indispensable. Legal predictions are constantly being made and must be acted upon. There is no man in business today who does not depend largely upon either explicit or implicit legal predictions in much of what he does. In this day of increasingly complex laws and regulations, the ability of even the ordinary citizen without a business of his own to live a happy and secure life and to stay out of jail depends upon his ability to make at least some legal predictions. Therefore, we must do the best we can with this problem and it is incumbent upon the legal profession to develop and utilize the best methods possible for the making of the most rational legal predictions.

To this end jurimetrics, or the employment of science in law, now offers great help. While the study itself has not yet been fairly initiated, from what we know already of science some conclusions can be ventured.

To begin with we must be clear that science offers us neither ultimate nor certain answers to legal problems. The dream that science might some day tell us which of several competing interests is the more important is a vain one. Science essays no such answers in any field. Science does not assign social or ethical values. Science may, indeed, provide data from which social or ethical judgments may be made; but the judgments will remain with man. Further, even as to the data and the principles which science may offer us, there will be no certainty. The data of science are stated in statistical terms and probabilities, and absolutes or certainties are, if nothing else, unscientific.

However, the indeterminacy and uncertainty of scientific data and principles are not to be taken as an impeachment of their validity or worth. On the contrary, these are intrinsic guaranties that the data and their validity are precisely as represented and are not overstated. These serve also to remind us that all human knowledge and experience is similarly uncertain, and indeterminate to a degree. We do not escape from the indeterminacy and uncertainty of science by postulating categorical absolutes. We merely deceive ourselves into supposing that we are wiser than we are, and court the possibility of error by overlooking the limitations of our knowledge and the extent of our ignorance.

The most promising immediate contribution that science proposes to make to the law is in automatic information retrieval. Within the last few years there has been an almost explosive development in the scientific methods of data retrieval. We now have available techniques of storing and retrieving data on punch cards, on peek-a-boo cards, on capacitor punched sheets, on microfilm, on micro-cards, on magnetic tape, magnetic discs or magnetic cards, on thermoplastic tape recorded by electron beams, as well as techniques for providing the continuous radio transmission of a body of data, and techniques of paging or identification systems for ordinary books or cards. Beyond the systems already in use or under development, experimentation in solid state electronics and utilization of radioactive isotopes, promises new and even more revolutionary developments.

While most of the systems that have been developed or designed so far involve substantial expense and rather elaborate machinery for utilization, even that obstacle to widespread use has already been virtually eliminated by other technical developments. It is now commonplace to transmit data directly from one electronic computing machine to another by telephone cable. When (and I do not say if) adequate facilities for electronic data storage and retrieval are developed for legal use, it is foreseeable that there need be only a few such facilities in relatively large areas. Private law offices may well be equipped with coding and decoding machines that are little larger or more complex than an electric typewriter, and which can be connected directly to a telephone line. In order to utilize the data stored in an electronic computer at some central location it will then be necessary only for the law office to call the central research facility, much as the library might be called by telephone today, and to have the office coding machine attached directly to the central computer by way of the telephone cable. In this manner a lawyer in any part of the country might undertake a direct research project in any law center equipped with the appropriate electronic equipment. While this may require more numerous or complex telephone lines than are now in service, the increase will be by no means proportionate to the additional utilization of the central research facilities. Automatic electronic searching, reporting and recording of data is so incredibly much faster than any other known means of handling similar data that only seconds will be required to complete what now takes hours of time by telephone conversation.

Actually the hardware—the mechanical devices—for permitting just such handling of legal data is already in existence. What is lacking is an adequate means of coding, indexing and retrieving the data that are to be handled. The software—the design of systems for utilizing the hardware—is what is now required. This involves an understanding of the intellectual instruments of science that have been referred to, plus an ability to employ these tools and improvise applications.

Considerable experimentation is now going on in a number of places with respect to the problems of coding and retrieving legal data by electronic means. One thing is already apparent. That is that present methods of digesting and classifying legal data are inadequate. There are a number of reasons for this. Perhaps the principal one is that the hierarchical method of classification upon which our present digesting and indexing system is built is essentially a closed end system which becomes too cumbersome when the material with which it deals expands as rapidly in quantity and variety as precedents, laws and regulations have in recent decades. Other defects are that the hierarchical system of classification is relatively inflexible and, therefore, adapts poorly to new subjects and new concepts. The digest itself necessarily depends upon the ability and insight of the person doing the abstracting as well as the one doing the searching. Therefore, any lawyer is subject to frustration in his legal research if the abstractor lacks skill, insight or imagination. In any event the task of abstracting and classifying is an immensely detailed and difficult one which may be quite unnecessary.

An alternative to the hierarchical classificatory system of indexing and digesting is a co-ordinate system in which data are identified either by concepts or by key terms, and located and retrieved by the coincidence of concepts or key terms used as co-ordinates. It is at least theoretically possible that the data in such a system might be stored in random order, except for classification by jurisdiction and the chronological sequence that will result from recording material as it is received. It is also possible that data so recorded and indexed need not be digested. It is quite possible that the coding may be done automatically by electronic optical scanning of the text and identification of words or phrases, either on the basis of frequency of occurrence, or of a predetermined list of significant words, or of both. It is further entirely possible that all of the recorded data, perhaps comprising even as much as all recorded American decisions to date, might be scanned completely in a few seconds of time, and all those containing specified words or phrases would be transmitted over a telephone line and printed in form for use so quickly as to be instantaneous by present temporal standards of legal research.

The advantages of such a system are so obvious as hardly to need detailing. To begin with, it is apparent that any such system could handle vastly more data in a fashion useful to lawyers than any presently existing system. One of the reasons that the volume of data usefully recorded would be much larger is not merely that it can be recorded in less bulky fashion, but also that it can be retrieved more quickly and identified more specifically and certainly by narrower, more numerous and more specific coding signals. Furthermore, the method of indexing, coding and retrieving need not be firmly established at the time the data are recorded. If the system is adequately designed initially, it would be quite possible to utilize combinations of terms, or co-ordinates, for the retrieval of data that were not conceived or utilized at the time the data were originally stored.

In this fashion the promise of modern scientific method is that it may free legal thinking from its bondage to established hierarchical systems of classification, while still permitting utilization of the common law method of decision by precedent. It is not too much to hope that electronic retrieval of data may give the common law a vitality and flexibility quite beyond the conception of lawyers of an earlier era. Further, it is not merely the common law case precedents that may be made readily available to the lawyers of the future. The system of electronic data retrieval should be equally applicable to statutes, administrative regulations and decisions, and eventually, to relevant data from other fields including the behavioral and the physical sciences. Thus, the limitations that are now put upon decision making by the sheer physical problem of searching out all of the potentially relevant data from legal and scientific sources may be largely eliminated.

As this frees decision making from the limitations of present facilities and methods, so will it also make legal prediction more reliable and secure. At the same time, the application of mathematical techniques of analysis and synthesis both to legal data and to specific factual situations, should permit the development of a calculus of legal prediction that will be of considerable assistance in establishing probability statements for the determination of specific legal issues.

It is impossible to say with any degree of assurance precisely how the art of legal prediction will be practiced with such developments. But at least the possibilities are evident. In the imminent future when jurimetrics has become a practiced discipline, when legal data become encoded, stored and retrieved electronically, and when lawyers have learned to cope with the mechanical and intellectual tools of science, the situation giving rise to legal questions will still, as now, be analyzed by a lawyer. Then, however, the crucial factual aspects may be reducible to a number of elements or factors.[19] These, in turn, may be quantified on an ordinal scale that has been constructed from statistical analyses of corresponding factors in previous cases. A mathematical description, or profile, of the case may then be constructed. On the basis of this, the most closely analogous precedents will be retrieved from the electronic library in which reports are stored. These may then be analyzed electronically by computer techniques to establish the degree of coherence (*i.e.*, central tendency) and inconsistency (*i.e.*, dispersion) among the precedents, the correspondence (*i.e.*, correlation) between the instant case and the sets of precedents, and the probability that the result of litigation will be that sought. The product will be a scientific prediction, stated in probability terms, and resting upon the validity of the analytical and statistical techniques applied to the underlying data. The proper interpretation and ap-

19. See LOEVINGER, *The Element of Predictability in Judicial Decision Making*, in PROCEEDINGS OF THE NATIONAL CONFERENCE ON LAW AND ELECTRONICS, U.C.L.A. 1960; Kort, *Predicting Supreme Court Decisions Mathematically*, 51 AM. POL. SCI. REV. 1 (1957); SCHUBERT, QUANTITATIVE ANALYSIS OF JUDICIAL BEHAVIOR (1959).

plication of such a prediction will require an understanding by the lawyer of the scientific techniques and concepts involved, just as diagnosis and prediction in fields now served by science requires a similar understanding.

There is no prospect of any process that will preclude consideration of social desirability or wisdom. The opportunity will always be available to argue that precedent should not be followed, and that considerations of policy, or expediency, require a different rule or a special result. Such arguments will be neither precluded nor determined by the more complete analysis and retrieval of data that science will afford. These advantages may not even stimulate the exercise of more thought or greater wisdom. But they will at least permit these, if we are inclined to make the effort entailed. The devices of science are more than new gadgets. They are entirely novel methods of manipulating recorded information that are as great an advance beyond present library techniques as printed books were beyond manuscripts. The intellectual instruments of scientific conceptualization are, within their sphere, similarly powerful new tools to extend the reach of the human mind. The effect of these mechanical and intellectual instruments depends entirely upon the use to which they are put.

It is important to keep in mind what it is that science promises and what it does not offer. Science does not and will not offer us any law machines that give automatic answers to specific questions put to them, whether as to particular cases or as to ultimate legal issues such as the relative importance of interests that may be in conflict. By the same token, science will provide us with no formulae or calculus that will give us certainty either of prediction, analysis or answers to ultimate questions such as which interest is to be preferred or which desire has greater social value. As with the printing press, the automobile, the electric light and the telephone, electronic data retrieval promises nothing more than certain new tools which we may use as well or as poorly as we are willing to make the effort.

On the other hand it is important to recognize that science does now, with the new wonders of electronics and data manipulation, offer us new tools that are potentially at least as powerful as the printing press, the automobile, the electric light and the telephone. It will require considerable effort on the part of the legal profession, first, to develop an effective vocabulary, taxonomy and logic fully to utilize these new instruments, and then to insure that the new developments are taught to the profession so that they may be generally employed. However, the legal profession probably has no choice. If it is to retain its position of intellectual leadership it must meet and master this great new intellectual challenge. If it does, it may find itself freed to lead society in advances that none of us now can envision. However, as we struggle to adapt the traditions and institutions of man's oldest discipline to the emerging and evolving miracles of man's newest intellectual achievements, we must keep in mind that it is not the machines that have changed mens' lives but the adaptions that men themselves have adopted in response to the machines. It is not the invention of tools, however subtle, complex or powerful, that constitutes man's greatest achievement, but the skill in using the tools that man has developed in himself.