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RESEARCH METHODOLOGY

R. O'Connor

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by

R. O'Connor

In his talk last week Dr. Kennedy outlined how he organised research and in the course of his address stated that he was concentrating on the nuts and bolts of the operation rather than on the more exciting intellectual matters of objectivity, causality, creativity, inspiration, induction and deduction.

It is my function to talk about the latter topics but in the time at my disposal I can cover very little of this ground. I propose therefore to confine my remarks to a discussion of research methodology or to what is known as "the theory of inquiry". As an introduction to this subject I will speak briefly about deduction and induction and conclude by giving an example of the application of these ideas in a practical situation.

As the discussion is concerned with research, it is useful to commence with a definition of this term. The Oxford Dictionary defines research as "a careful search or inquiry to discover new facts by scientific study of a subject, or to investigate closely". This is a rather broad definition which tells us generally what the subject is about but little else. Within this broad spectrum however, there are various kinds of research ranging from pure description to advanced analysis. To my mind however, all research is concerned in some way with the solution of problems even though the problems are not always stated explicitly. For example people say they require information on a particular topic and set about having it obtained. They may not always say why they require the information but it can be taken that they need it for some purpose and in the absence of a more explicit reason the purpose can be considered as the problem. Thus we can conclude that research is always designed to solve problems of some kind.

Philosophers recognise two basic methods of problem solving. The first is known as the deductive, apriori or syllogistic method, known also as the mathematical method, since it is the method used in the solution of mathematical problems. The second is called the inductive, aposteriori or empiric method. This method is often referred to as the scientific method, since some people believe that is is by this method and this method only, that scientific as distinct from purely mathematical problems can be solved. Each of these methods is discussed below.

The Deductive Method

The simplest form of deductive argument is the syllogism which consists of three categorical propositions. Two of these propositions are called premises and must have a common term, while the third which derives logically from the first two is known as the conclusion. The following is an example of a syllogism.

> All anarchists are a danger to society. John Murphy is an anarchist. Therefore John Murphy is a danger to society.

The first two of the above statements are the premises, having the common term anarchist in each, while the third is the conclusion which follows logically from the first two.

It should be pointed out however that syllogistic reasoning is not always as simple as the above proposition implies. Indeed the method is full of pitfalls and unless the premises are carefully stated erroneous conclusions may easily be drawn from them. False conclusions of this kind are known in logic as fallacies and all logical text books devote some space to such topics.(1) In this talk however I do not intend discussing fallacies or fallacious arguments but instead will concentrate attention on the more positive aspects of deduction.

Mathematical Deduction

Though many of us may never have heard of the syllogism or of say other logical propositions we are all familiar with deductive reasoning through our knowledge of Euclidean geometry. This subject displays the deductive process in its purest form. Using the methods of Euclid we take as given, certain axioms, definitions and propositions already proved and then proceed in a purely deductive way to prove certain other theorems or hypothesis which have been propounded. The definitions are a safeguard against using the wrong concepts while the axioms are self evident truths which are taken as given. For example in Euclidean geometry a point is defined as something which has location but no magnitude, a line is something which has length but no breath,while it is held as axiomatic that the shortest distance between two points is a straight line. The hypothesis or theorem is something to be proved and on the basis of the definitions and axioms it can be shown deductively whether or not the hypothesis is correct.

This method of deduction however is not always operated as described above even in mathematics. Cohen and Nagle[2] state "that mathematics as an inquiry did not historically begin with a number of axioms from which subsequently the theorems were derived. We know that many of the propositions of Euclid were known hundreds of years before he lived: they were doubtless believed to be materially true. Euclid's chief contributions did not consist in discovering additional theorems but in exhibiting them as part of a system of connected truths. The kind of question Euclid must have asked himself was: Given the theorems .... what are the minimum number of assumptions or axioms from which these can be inferred .... The axioms were thus in fact discovered later than the theorems, although the former are logically prior to the latter".

It is also true that other famous scientists have performed in exactly the same manner as Euclid, but the number of such people is rare. The Euclids, the Keplers, the Newtons, and the Einsteins, appear on the scene at rare intervals only, and by their brilliant insights change the whole structure of contemporary thought. Ordinary competent scientists on the other hand, come in a much more orthodox mould but in their own way they perform valuable work. These are the people who consolidate positions after the brilliant forward leaps and integrate new and old ideas into fresh schemes and acceptable interpretations.

Deduction in the Physical Sciences

As can be gathered from the above statements the deductive method had its roots in ancient learning, and according to Plato and his contemporaries it was the supreme scientific method. As Lanczos says:- [(3)]

> "The Greek scientists and philosophers were convinced that the supreme architect of the universe was also a supreme geometer. Geometry was a divine occupation, a kind of divine worship. And thus it did not seem in the least inadequate that the same method which leads in geometry to such supreme results should also be applicable to the exploration of the physical universe".

Unfortunately however this has not proved to be the case. Though the reasoning involved in going from presmise to conclusion may be absolutely correct, erroneous conclusions may be derived because the intitial premise (though apparently self-evident) is not correct. For example, most of the familiar results in the physical sciences are based on the Euclidean axiom that the shortest distance between two points is a straight line, but modern physicists by not accepting this apparently self-evident truth have arrived at results which have advanced physical knowledge far beyond that of the Euclideans.

The biggest difficulty however with the <u>purely</u> deductive approach (and I underline the word purely) is that we work always on the basis of pure reasoning and do not use all the evidence available to us. We take no account of observation. To this Plato would have replied that one cannot expect to verify a deductive law of geometry by physical instruments, and though this may be true for mathematicians, the failure to use empirical checks on physical results derived deductively, has in the past, led scientists to accept very erroneous views about the laws of the universe. As we know, many deductive philosophers would not accept that the earth moved round the sun even after Galileo had looked into his telescope and discovered the existance of the planet Jupiter and the phases of Venus. But apart from this the Greek philosophers considered it degrading to use geometry for any purpose of vulgar utility. Macauley(4) in his famous essay on Bacon says: "Archytas, it seems had framed machines of extraordinary power on mathematical principles. Plato ... declared that this was to degrade a noble intellectual exercise into a low craft fit only for carpenters and wheelrights". "The office of geometry" he said, "was to discipline the mind not to minister to the base wants of the body". Thus it was that the deductive process was put into a straight-jacket in which it remained for centuries.

The Inductive Method

Modern science is often contrasted with the science of antiquity as being inductive rather than deductive, Also many people subscribe to the view that the inductive method was invented by Sir Francis Bacon. Both these statements are untrue. Though Bacon described the inductive method in great detail in the Novum Organum he did not more than popularise it, in the course of propounding his famous philosophy of utilitarianism.

As Macauley says "the inductive method has been practiced ever since the beginning of the world by every human being. It is constantly practised by the most ignorant clown, by the most thoughtless schoolboy, by the very child at the breast. The method leads the clown to the conclusion that if he sows barley he shall not reap wheat. By that method the schoolboy learns that a cloudy day is the best for catching trout. The very infant we imagine is led by induction to expect milk from his mother or nurse, and none from his father".[5]

Neither is it true to say that Bacon was the first person who correctly analysed the inductive method and explained its uses. Aristotle had long before pointed out the absurdity of supposing that syllogistic reasoning could ever conduct men to the discovery of any new principle and had attempted to show that such discoveries must be made by induction and induction alone. Indeed Aristotle seems to have subscribed to the view that inductive and deductive reasoning are antithitical modes of inference; that the way to establish a universal proposition is by an exhaustive study of the facts or by letting the facts speak for themselves.

Macauley[6] describes the inductive method rather amusingly when he says: "the inductive method is an analysis of what we are all doing from morning to night and which we continue to do even in our dreams. A plain man finds his stomach out of order. He never heard Lord Bacon's name, but he satisfies himself that minced pies have done the mischief. 'I ate minced pies on Monday and Wednesday and I was kept awake by indigestion all night. I did not eat any on Tuesday and Friday and I was quite well. I ate very sparingly of them on Sunday and was very slightly indisposed in the evening. But on Christmas day I almost dined on them and I was so ill that I was in great danger. It cannot have been the brandy I with them, for I have drunk brandy for years without being the worse for it' and so he concludes that mince pies are the cause of his trouble.

"But though everyone is constantly performing the process described some men perform it well and some badly. Some are lead by it to truth and some to error. It led Franklin to discover the nature of lightning. It led thousands who had less brains than Franklin to believe in animal magnetism and one eminent judge to propound the theory that the cause and prevalence of Jacobinism was the practice of giving people three names."

Macauley and many others as well, claimed that by the inductive method alone new truth could be discovered. This is now disputed. According to Cohen and Nagle(7) "it is an utterly superficial view to assume that the truth is to be found by just studying the facts", for as they say; "What are facts and which facts should we study? There are no rules of induction which tell us this and if we employ the inductive process blindly we will end up asking the wrong questions and collecting useless facts."

"Induction is also superficial because no inquiry can even get underway unless and until some difficulty is felt in a practical or theoretical situation. It is this difficulty or problem which guides our search for some order among the facts, in term of which the difficulty is to be removed or the problem solved." How does such a search for an order among facts proceed?

The Modern Scientific Method - a synthesis of deduction and induction

According to the modern logicians we cannot take a single step forward in any inquiry unless we begin with a suggested explanation or solution of the difficulty which originated it. Such tentative explanations are suggested to us by something in the subject matter and by our knowledge and experience. When these explanations are formulated as propositions they are called hypotheses. The function of the hypothesis is to direct our search for order among the facts. The suggestions formulated in the hypothesis may be solutions to the problem, and whether they are or not is the task of the inquiry.

The rules of the modern scientific method may be stated briefly as follows:-

(1) State the problem clearly or enumerate what it is you want to discover, defining your concepts and stating your assumptions. In the ideal model certain concepts are taken as undefined (primitive) and other concepts are defined in terms of these. The choice of undefined concepts is to a certain extent arbitrary.[8]

(2) Think up a likely solution or solutions to the problem or in other words make an hypothesis as to what the solution really is.

(3) Decide on the data required to test the hypothesis, on the means of collecting the data, and on the methods of classification or analysis to be adopted.

(4) Collect the required data, analyse them, draw conclusions and write up the results.

For some problems this procedure is relatively simple to envisage and implement, but for others it may not work exactly in the way specified. This is likely to be true with descriptive research, but even here if we can visualise a reason for doing the work or the uses to which the results will be put, then we can decide exactly what data to collect, what reading to do and how the presentation will be made. In this case (as stated at the start) the reason for the work may be considered as the problem for which a hypothesis can be ennunciated. The fundamental thing to remember however is that the hypothesis directs all subsequent effort; without the hypothesis we will not know what to do.*

Proponents of the strict inductive method will argue that we can never formulate an hypothesis without first having done a certain amount of observation and examination. This is true. If we are asked to do a study of something about which we know little or nothing, then we must do a reading review before we can go any further. If however there is nothing written or known about the subject then, we have to talk to people, make observations and pilot studies until a stage is reached where we can outline a problem and form some fairly realistic hypothesis about its solution. After this we can go ahead with a proper research of the area. Thus it is clear that we must get to know the primary premises by induction. After that the deductive method is used, but not the sterile deduction of the ancient Greeks, but a method which uses intuitive logic and observed facts.

Practical Application of the Scientific Method in a Field Study

I would now like to talk about the first really large scale field survey I did, in order to see how it fits into the scheme of things as described above. This survey was the National Farm Survey carried out by C.S.O. over three years between 1955 and 1958.

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* Sometimes of course we may be unable to test the hypothesis adequately. This however must not discourage us too much. Many accepted truths are untested hypothesis.

The objective of the farm survey was to determine income and expenditure of farmers of different sizes and types, in different regions of the state, classified by type of income and expenditure, i.e. income from cattle, sheep, pigs, dairying etc., and expenditure on feeds, fertiliser, seeds, machinery etc. Where to fit problem and hypothesis into this study is difficult to visualise at first,but because we set out to collect data in this area, implied that there was a problem, and because we decided to classify the data, as we did, implied an hypothesis.

The main questions which required answering were:-

(1) What was the overall incomes of farmers in the state. For the previous ten years C.S.O. been preparing farm output and expenditure figures on the basis of global statistics. It was vital therefore that these statistics be checked by actual farm figures.

(2) How did farmers incomes compare with incomes in other sectors.

(3) How were the income and expenditure figures distributed as between different enterprises and different sizes of farms in different regions.

Some of the hypotheses which could be enumerated were:-

(1) Farm workers' incomes are lower than incomes of non-farm workers. Therefore we must find out in addition to the overall income, the number of workers and the times worked. We must also pay close attention to our definition of farm income, if it is to be comparable with other incomes.

(2) Incomes of small farmers are lower than those of large farmers, therefore we must classify farms by size, and see that the sample includes a sufficient number of the required sized farms.

(3) Incomes of cattle farmers are lower than those of dairy or tillage farmers, hence we must classify by type of farm.

(4) Incomes of farmers of the same size and type are lower in the west of Ireland than in the east, hence we must classify by region.

(5) Farmers who use fertiliser and certain other inputs have higher incomes than those who don't use these. Hence we must classify our inputs and so on.

The first main objective of the survey was to collect the data required to test these hypotheses. This was to be done by asking 2,000 farmers of different sizes in the state to keep accounts. I will not go into the selection of the sample here except to say that it was drawn on the basis of the hypotheses i.e. we insured that it contained sufficient numbers of the different kinds of farmers required.

While the sample was being selected I set about preparing the farm account book in which the data were to be collected. Before commencing this operation however the Director, Dr. R.C. Geary announced that we must first prepare the blank tables in which the data would be published. I said that I could not prepare tables until I had data, but he would have none of this. He said "unless we know exactly what we want and define it carefully we cannot embark on an expensive survey. He also stated that having a pile of completed account books on the desk at the end of the year would not help in any way with the preparation of tables. Experience since has shown me that Geary was absolutely correct in this regard. In order to prepare tables we must visualise certain relationships between variables, and the availability of a mass of data is no help in this regard.

Thus it was that I started to prepare blank tables before any data were collected in the field. I soon found however that I could not do this on my own as I did not know at the time what figures the C.S.O. really wanted. There then followed a series of discussions with most of the senior people in the Office and after a period of about two weeks we agreed on the layout and headings for the main account book summary table. At this stage we also defined carefully the items to be included in the summary table and dedided on the method of valuing all inventories. The time and effort taken to prepare the summary table and define terms gives some idea of the importance which C.S.O. experts attached to specifying the data needed, and to ensuring that uniform definitions were observed on all farms.

When the summary table was designed,I prepared the account book to give the required information,and wrote up the agreed definitions for the field surveyors. Later I prepared a series of blank tables for publication. These were designed on the basis of the hypotheses mentioned above and were to ensure that the main summary table in the book was fully comprehensive.

The next stage in the work should have been a pilot survey but as I had previously done a number of similar smaller studies a pilot was not considered necessary. We therefore went ahead with the main survey by briefing enumerators and canvassing farmers co-operation. During this stage there was constant contact with the field staff to help with the various problems which arose. I also visited them regularly and examined the account books to ensure that the latter were being completed properly.

At the end of the first year the completed account books were carefully checked in the office. The checking staff were given a set of rules, and account books not conforming to the rules were queried. About 40 per cent of all books were returned to enumerators on query. This indicates how careful one has to be with field data. It must always be carefully scrutinised not alone by the survey unit people but also by the research worker. If a research worker does not stay close to his data all the way through he will be in trouble.

When the data were all checked they were punched on cards and the blank tables completed from these cards. The tables gave us all the information we required at the time, but the data were used afterwards by the C.S.O. and outside workers for regression analysis.* The hypotheses tested in these regressions had however been envisaged before the data were collected.

Summary

Philosophers recognise two basic methods of problem solving known as the deductive and inductive methods. Using the deductive method we start with a hypothesis or theorem to be proved and then by a process of pure reason we accept or reject the hypothesis on the basis of certain accepted definitions and axioms.

The main difficulty associated with the purely deductive method is that we work on the basis of pure reasoning and do not use all the information available to us. We take no account of

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* One important study based on the data was "Production Functions Analyses of Irish and British Farm Accounts" by Knud Rasmussen with M.M. Sandilands. Department of Agricultural Economics, University of Nottingham, Sutton Bonnington, June 1962.

observation. In the past failure to use empirical checks on results derived deductively led scientists to accept erroneous views about the laws of the universe. This arose because the basic axioms used were incorrect.

By induction is meant the establishment of universal truths by exhaustive examination of all the facts relating to problems. Those who favour the inductive approach exhort us to study relevant data and let the facts speak for themselves. According to modern philosophers however it is an utterly superficial view to assume that truth can be found in this way, for they say "What are facts?" and "What facts should we study?" Unless we can make some hypothesis about the solution we can never know what facts to gather or how we should classify data when collected. It is held therefore that we can never solve scientific problems either by pure deduction or pure induction. We must use a combination of both methods.

The approach to problem solving should proceed in the following order:

(1) State the problem clearly or outline what is to be discovered.

(2) Think up a likely solution or solutions to the problem, or in other words make an hypothesis as to what the solution is.

(3) Decide on the data required to test the hypothesis, on the means of collecting the data and on the methods of classification or analysis to be adopted.

(4) Collect the data, analyse them, draw conclusions and write up the results.

For some problems this procedure may not work exactly in the way specified. This is likely to be true with descriptive research,but even here if we can visualise a reason for doing the work or the uses to which the results will be put we can de decide on the data to collect and on the method of presenting it. In this case the reason for the work may be considered as the problem from which an hypothesis can be propounded. If however we know nothing about a subject which we wish to study then we have to talk to people and make observations until we reach a stage where we can outline a problem and form some realistic hypothesis about its solution. After this we can go ahead with a proper research of the area.

In doing field studies (which are always very expensive) we should decide on the data to be collected, define carefully the terms to be used and make a set of blank tables for publication before any field work is done. Very often the blank tables are designed even before the questionnaire is prepared. If this procedure is not adopted we may collect useless data or omit information which is necessary for the inquiry. Finally, careful instructions should be written out for the field staff. The research worker should keep in close touch with the field operation at all stages and with the checking of completed questionnaires.

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