W A Wijewardena: Scientific research – what researchers should do and should not

Keynote address by Mr W A Wijewardena, Deputy Governor of the Central Bank of Sri Lanka, at the 3rd International Research Conference, organized by the Faculty of Management & Finance, University of Colombo, Colombo, 11 December 2008.

The views expressed in this paper are those of the author and should not be construed as those of the Central Bank of Sri Lanka.

*   *   *

A Master Debater has once boasted that he normally employs three ploys to subdue his difficult customers. ***"When I find that my opponent is not easily surmountable, I use mathematics, philosophy and religion to subdue him"**.* He has confessed. ***"Mathematical equations frighten him, philosophical expressions confuse him and religious sayings make him feel guilty. After that, he is an easy prey for the final onslaught".*** He has further elaborated triumphantly. The superior property of mathematical equations in frightening intellectual opponents is not without precedent. An example in this connection has been presented by Astro-physicist Carl Sagan in his ***Broca's Brain*** (p. 151). According to the story, the French encyclopaedist Diderot, being an atheist himself, had challenged anyone to prove the existence of God during a visit to Russian Empress Catherine's court. When he became an embarrassment to everyone, Euler, the master mathematician and also a temporary visitor to the Court, is said to have accepted the challenge. Euler has said, ***"Sir, $(a + b^n)/n = x$, therefore God exists. Disprove"***. The mathematics-phobic Diderot, being unable to respond, is said to have fled the Court! These examples suggest that people can sometimes use gimmicks to confuse opponents and win arguments. Such winnings do not prove or disprove any proposition. They do not add knowledge to the extant body of knowledge. They simply help a crafty person to make a temporary escape from an existing difficult situation.

Scientific research is different from the employment of gimmicks to gain temporary winnings. It is the method of using human intellect to discover new knowledge and add that wisdom to the existing body of knowledge until it is disproved by a new discovery. Hence, those who are engaged in scientific research have to conform to a set of accepted principles, guidelines and a code of ethics and morality. To follow such a set of rules when playing the game called scientific inquiry is not an easy task. Yet, one has to do so in order to separate science from what is sometimes known as **pseudo-science**.

Why scientific research?

Human knowledge is as old as the history of human beings. Human beings have attempted to understand **Nature**, by using **human intellect and experience**, so that they could find answers to questions that had been puzzling them constantly. Some of these questions have been beyond direct observation such as ***"who created the world?"*** or ***"what caused rains?"***. Hence, it is quite natural for them to **hypothesise** answers by using both intellect and experience. When they do so, it is also inevitable for them to base their conclusions on personal **biases, fears and prejudices** they have been harbouring in their minds. Such conclusions are tainted by biased or prejudiced views held by the person making the conclusions. Hence, such findings are simply an imposition of personal views on the society and, therefore, fail to explain **reality** and **Nature**. Therefore, discoveries made in that manner do not enhance the **human knowledge**.

In this background, it is necessary to build the knowledge base of mankind free from biases, fears and prejudices. This could be attained by pursuing **scientific inquiry** which bases itself on a set of principles, guidelines and an ethical and moral code that discipline the researchers. It should, however, be noted that the conclusions derived through scientific inquiry are not static and permanent. The very nature of scientific inquiry is that conclusions derived from a given research study, as **Karl Popper** pointed out, should be capable of being refuted by a new inquiry. Hence, results produced by scientific research carry with them **the property of refutability** and are valid only until a new research study would replace them with new results. In this sense, the knowledge base developed through scientific inquiry could be equated to a reservoir from which water would flow out and fresh water would flow in continuously. But the core knowledge, just like the permanently stored water in the reservoir, would remain intact.

The mind of a researcher engaged in scientific inquiry

There are certain qualities and prerequisites which a researcher engaged in scientific inquiry should possess. The most important of these is the **open mind** with which the researcher should commence his inquiry. The researcher is not a propagandist, nor is he a person bent on superimposing his views on others. He should be humble enough to reject even the views he would have held for long, if his inquiry does not support them. In other words, he should conduct his inquiry, not with the objective of establishing the views held by him, but with the objective of subjecting them to a free inquiry. This is known as **rational** and **objective** thinking.

The Buddha, in a discourse He preached to members of *Kalama* clan, outlined the nature of rational and objective thinking, though its purpose was to guide them to distinguish good from bad. ***"Oh, Members of Kalama clan…"* the Buddha said. *"…Do not rely on an opinion because you have heard it often and you are familiar with it. Do not accept it because it is in accord with tradition or found in the scriptures or logical or conforms to theory. Do not accept it because it is preached by your teachers or by a respected priest"* (*Anguththara Nikaya).*** The researcher who plans to engage himself in scientific inquiry should be free from the influence of previous knowledge or the traditions and should not be guided by mere logical considerations.

How could an individual understand the nature of the real world? There are two approaches suggested for this purpose, namely, **classicism** or **romanticism**. Classicism shows the world by means of its underlying form. It proceeds by **reason** or by **laws** governing Nature. If a motor car engine is presented to a classicist, he would be interested in finding out its underlying mechanism as determined by mechanical laws governing the working of the engine. A romantic, on the other hand, would simply be interested only on the outer surface of the world. He would look at the world from the point of its immediate appearance. Hence, a romantic would find a motor car engine with wires and cables strewn everywhere in a disorderly manner as a dull appearance.

A person with a scientific mind would get himself embroiled in classicism and not in romanticism. This is because romanticism is concerned about emotions – feelings like biases, fears or prejudices which a scientist should avoid when undertaking a **scientific inquiry**.

What is scientific method?

Robert M Pirsig, the philosopher-novelist, in his novel titled ***Zen and the Art of Motorcycle Maintenance***, raises a very pertinent question regarding scientists and scientific inquiry. Is a sideway motorcycle mechanic a scientist? The answer depends on how the motorcycle mechanic would apply himself to the problem at hand.

According to Pirsig, if a motorcycle mechanic does a lousy job, then he does not qualify himself to be called a scientist. There are many mechanics of this type. When a faulty motorcycle is brought to a mechanic, he may simply jump to conclusions based on his previous knowledge. Instead of subjecting the motorcycle to a thorough scientific inquiry, he may conclude that the fault lies in a certain part or a certain mechanism. To reach this conclusion, he has not gathered the relevant information. The chances are that he may be correct or may not be correct. If he is correct, the repair performed on the basis of the diagnosis made with imperfect information will prove to be a success. But the mechanic in that case has behaved like a **speculator** and the outcome of **speculation** may have the chance of being a success or a failure. If it turns out to be a failure, the cost to the owner of the motorcycle would be enormous. In that case, since the correct repair has not been performed, the motorcycle will continue to remain faulty. Hence, a true scientist engaging himself in scientific inquiry should not be a speculator. Instead, he should be a person willing to follow the scientific method to arrive at conclusions.

Decisions could be made by a mechanic attending to a faulty motorcycle by resorting to either **inductivism** or **deductivism**. The **inductive approach** requires the mechanic to look for evidence in the real world and come to conclusions. For instance, if we see crows that are black and if we continue to see black crows, we may conclude that all crows are black. A motorcycle mechanic may likewise see the faulty part and conclude that the fault lies in that part. The **deductive approach**, on the other hand, requires the mechanic to theorise in his mind and come to conclusions based on empirical findings he would make to support his theory. In the previous black crow example, we may theorise that crows are black and then look for black crows in the real world. When we find one black crow, our theory is proved.

A motorcycle mechanic becomes a scientist, if he follows the scientific method in the diagnosis of the fault and the subsequent repair of the motorcycle. It involves starting with an open mind. There are no previously made conclusions or prejudgments. The approach is simply classical, that is, guided by underlying principles and not by the immediate appearance. There are several steps which a scientist should follow when he adopts the scientific method. A good motorcycle mechanic would also follow the same steps.

The steps involved in a scientific inquiry are as follows.

First, the identified **problem** has to be stated in clear terms. In the case of a motorcycle, the problem may be that the engine does not start.

Second, based on the problem, one **hypothesis** or several **hypotheses** as required regarding the cause of the problem should be made. The motorcycle engine does not start because there is no fuel in the tank. Or there is a blockage of the tube that distributes fuel to the engine. Or the electrical system may have failed. Or carburettor would have been blocked. The mechanic would hypothesise all possible reasons for the failure of the engine.

Third, experiments are designed to test each hypothesis made. The mechanic may open the fuel tank to see whether there is fuel. If there is no fuel, he will try to start the engine having filled the tank with fuel. If there is fuel in the tank, then he would examine the second hypothesis, that is, whether there is a blockage in the tube that distributes fuel to the engine. If there is a blockage, he will clean it and try to start the engine. If there is no blockage, then he would experiment the third hypothesis, namely, the working of the electrical system. In this manner, he would experiment all the hypotheses he has made one by one and make relevant conclusions.

Fourth, the results of the experiments are analysed in order to ascertain whether the hypothesis is proved. Or else, when several hypotheses have been made, to ascertain which hypothesis has been proved.

Fifth, making final conclusions out of the observed results of the experiments.

A disciplined motorcycle mechanic would follow these steps involved in the scientific method and attend to the required repair of the fault in the motorcycle. In this sense, a sideway motorcycle mechanic is not different from a trained scientist, since both follow the scientific method in reaching conclusions.

The use of techniques and technology

It has been fashionable for scientists to make use of scientific **techniques** and **technology** to facilitate the decision making process, when undertaking scientific inquiries. Extreme care should be exercised by scientists in this instance. Every technique has its own methodology and limitations and the scientist should be fully aware of same when such techniques are used. Inappropriate use of the techniques or wrong conclusions made on the basis of the results derived amount to misuse of science by the researchers. It also paves way for crafty individuals to use the results to their advantage and gullible individuals to get victimised.

The use of **econometrics** has been one of the techniques employed by scientists to prove or disprove their hypotheses. This has also been one of the sources of misuse of science, either because wrong calculations are made or wrong conclusions are arrived at, due to the failure of the researcher to analyse the error term appropriately. ***Wikipedia**,* the cyber-encyclopaedia, is full of the instances of such misuse of econometric methods in research. It is noteworthy to refer to two studies done by Deirdre N McCloskey and Stephen T Ziliak of the University of Iowa on the status of econometric studies in research articles published in the reputed journal ***American Economic Review*** in 1980s. They have found fault with authors for not analysing the error term properly and using the statistical term "significance" inappropriately. One of their papers published in the ***Journal of Economic Literature*** in March, 1996 under the title "The Standard Error of Regressions" has made the following eye-opening comment: ***"Such misuses of statistical significance appear to depend in part on a vintage effect, measured by date of Ph.D. conferral. The papers authored by Ph.D.s conferred between 1975 and 1979, when inexpensively generated t-tests first reached the masses, were considerably worse than the papers of others at making a distinction between economic and statistical significance. They used the word "significance" in ambiguous ways more often than did early or later Ph.D.s and they were less likely to separate statistical significance from other types of significance in the sections on scientific and policy implications"*** (p 111).

The other findings of McCloskey and Ziliak are also startling. Of the 182 articles in the ***American Economic Review*** they have surveyed, 70 percent had not distinguished statistical significance from economic, policy or scientific significance. While they had referred to largeness of the estimators, 72 percent had not asked "how large was large?" At the same time, 59 percent had used the word "significance" in ambiguous ways. A more pronounced failure has been the non-reporting of descriptive statistics such as the means of the regression variables by 69 percent of the authors. (p 106).

The problem with econometric studies is that the computations made by authors remain as a **"black box"** to ordinary readers. It is the responsibility of the editors of journals to verify the black box and assure quality on behalf the general public who consumes the outcome of research studies. It is, therefore, disheartening that learned journals have published such papers without due reference and consideration of the methodology adopted in conducting the research under reference. Today, of course, with advanced statistical packages available, it is possible for the editors of the journals to check on the appropriateness of the statistical calculations made by the paper writers. Since the ordinary readers of scientific papers are unable to gauge the wrongful way of handling econometrics by researchers, such studies by editors before papers are published become all the more important. In view of the gullibility of general readers, the misuse of econometrics in learned papers is akin to **"mis-selling"** that one finds in the market place when a seller has not fully apprised a buyer of the risks of buying a product. This type of mis-selling by researchers could be termed **"econometric dishonesty"** which they are not supposed to practise.

Researchers find a truth and not the truth

The real world is vast and complex. Hence, it cannot be mapped out by scientific research adequately, just like neurologists are unable to map out the human brain completely. What the science does is to discover only a flint of **the truth** in the vast real world. As such, there is no dearth of hypotheses which scientists could make and a dearth of theories which they can formulate. That is good news for prospective scientists. However, one theory which is valid today could be disproved by another theory to be formulated tomorrow. Hence, all theories are subject to the same property: the property of refutability. In fact, Karl Popper's argument was that if a theory cannot be refuted, then it does not become a theory.

Hence, any scientific research will discover only **a truth** and not **the truth**. This means that all scientific research studies undertaken in all the disciplines would produce only a **relative truth** and not the **absolute truth**. With all the scientific apparatuses, techniques and computing capacity available today, science still cannot reach out to the absolute truth. As such, the task of finding the absolute truth has been relegated to religion and mystics.

This may be discouraging news for those who are engaged in scientific research. But, that has been the way of science throughout its history and such discovery of relative truth has been adequate for the purpose of building the human knowledge base and putting it to practical use by mankind. In the modern world, the discovery of absolute truth may therefore be irrelevant.

Conclusions

A researcher is not a propagandist or a dictator. His task is to follow an accepted set of principles, guidelines and an ethical and moral code to discover a truth, and not the truth, and add it to the extant knowledge base. He should start his inquiry with an open mind and be ready to reject even the long held views if empirical studies do not support them. But to do so, a researcher should display a fair degree of maturity and necessarily cultivate within himself self-discipline, wisdom, objectivity and equanimity. In this sense, a perfect researcher is like the Buddha who is not guided by biased or prejudiced emotions.

Hence, the most important requirement of a researcher is that he should be honest to himself.