

work. An introductory college level text book in physics will likely contain separate chapters devoted to each of these theories. Similar theories are also available in social sciences. For instance, cognitive dissonance theory in psychology explains how people react when their observations of an event is different from what they expected of that event, general deterrence theory explains why some people engage in improper or criminal behaviors, such as illegally download music or commit software piracy, and the theory of planned behavior explains how people make conscious reasoned choices in their everyday lives.

The goal of scientific research is to discover laws and postulate theories that can explain natural or social phenomena, or in other words, build scientific knowledge. It is important to understand that this knowledge may be imperfect or even quite far from the truth. Sometimes, there may not be a single universal truth, but rather an equilibrium of “multiple truths.” We must understand that the theories, upon which scientific knowledge is based, are only explanations of a particular phenomenon, as suggested by a scientist. As such, there may be good or poor explanations, depending on the extent to which those explanations fit well with reality, and consequently, there may be good or poor theories. The progress of science is marked by our progression over time from poorer theories to better theories, through better observations using more accurate instruments and more informed logical reasoning.

We arrive at scientific laws or theories through a process of logic and evidence. Logic (theory) and evidence (observations) are the two, and only two, pillars upon which scientific knowledge is based. In science, theories and observations are interrelated and cannot exist without each other. Theories provide meaning and significance to what we observe, and observations help validate or refine existing theory or construct new theory. Any other means of knowledge acquisition, such as faith or authority cannot be considered science.

Scientific Research

Given that theories and observations are the two pillars of science, scientific research operates at two levels: a theoretical level and an empirical level. The theoretical level is concerned with developing abstract concepts about a natural or social phenomenon and relationships between those concepts (i.e., build “theories”), while the empirical level is concerned with testing the theoretical concepts and relationships to see how well they reflect our observations of reality, with the goal of ultimately building better theories. Over time, a theory becomes more and more refined (i.e., fits the observed reality better), and the science gains maturity. Scientific research involves continually moving back and forth between theory and observations. Both theory and observations are essential components of scientific research. For instance, relying solely on observations for making inferences and ignoring theory is not considered valid scientific research.

Depending on a researcher’s training and interest, scientific inquiry may take one of two possible forms: inductive or deductive. In **inductive research**, the goal of a researcher is to infer theoretical concepts and patterns from observed data. In **deductive research**, the goal of the researcher is to test concepts and patterns known from theory using new empirical data. Hence, inductive research is also called *theory-building* research, and deductive research is *theory-testing* research. Note here that the goal of theory-testing is not just to test a theory, but possibly to refine, improve, and extend it. Figure 1.1 depicts the complementary nature of inductive and deductive research. Note that inductive and deductive research are two halves of the research cycle that constantly iterates between theory and observations. You cannot do inductive or deductive research if you are not familiar with both the theory and data

components of research. Naturally, a complete researcher is one who can traverse the entire research cycle and can handle both inductive and deductive research.

It is important to understand that theory-building (inductive research) and theory-testing (deductive research) are both critical for the advancement of science. Elegant theories are not valuable if they do not match with reality. Likewise, mountains of data are also useless until they can contribute to the construction of meaningful theories. Rather than viewing these two processes in a circular relationship, as shown in Figure 1.1, perhaps they can be better viewed as a helix, with each iteration between theory and data contributing to better explanations of the phenomenon of interest and better theories. Though both inductive and deductive research are important for the advancement of science, it appears that inductive (theory-building) research is more valuable when there are few prior theories or explanations, while deductive (theory-testing) research is more productive when there are many competing theories of the same phenomenon and researchers are interested in knowing which theory works best and under what circumstances.

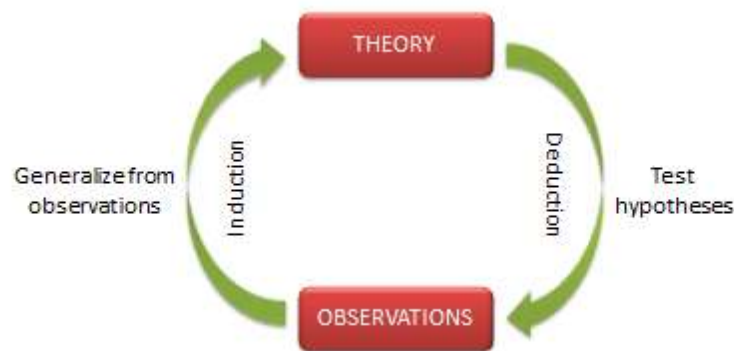


Figure 1.1. The Cycle of Research

Theory building and theory testing are particularly difficult in the social sciences, given the imprecise nature of the theoretical concepts, inadequate tools to measure them, and the presence of many unaccounted factors that can also influence the phenomenon of interest. It is also very difficult to refute theories that do not work. For instance, Karl Marx's theory of communism as an effective means of economic production withstood for decades, before it was finally discredited as being inferior to capitalism in promoting economic growth and social welfare. Erstwhile communist economies like the Soviet Union and China eventually moved toward more capitalistic economies characterized by profit-maximizing private enterprises. However, the recent collapse of the mortgage and financial industries in the United States demonstrates that capitalism also has its flaws and is not as effective in fostering economic growth and social welfare as previously presumed. Unlike theories in the natural sciences, social science theories are rarely perfect, which provides numerous opportunities for researchers to improve those theories or build their own alternative theories.

Conducting scientific research, therefore, requires two sets of skills – theoretical and methodological – needed to operate in the theoretical and empirical levels respectively. Methodological skills ("know-how") are relatively standard, invariant across disciplines, and easily acquired through doctoral programs. However, theoretical skills ("know-what") is considerably harder to master, requires years of observation and reflection, and are tacit skills that cannot be "taught" but rather learned through experience. All of the greatest scientists in the history of mankind, such as Galileo, Newton, Einstein, Neils Bohr, Adam Smith, Charles

Darwin, and Herbert Simon, were master theoreticians, and they are remembered for the theories they postulated that transformed the course of science. Methodological skills are needed to be an ordinary researcher, but theoretical skills are needed to be an extraordinary researcher!

Scientific Method

In the preceding sections, we described science as knowledge acquired through a scientific method. So what exactly is the “scientific method”? **Scientific method** refers to a standardized set of techniques for building scientific knowledge, such as how to make valid observations, how to interpret results, and how to generalize those results. The scientific method allows researchers to independently and impartially test preexisting theories and prior findings, and subject them to open debate, modifications, or enhancements. The scientific method must satisfy four key characteristics:

- *Logical*: Scientific inferences must be based on logical principles of reasoning.
- *Confirmable*: Inferences derived must match with observed evidence.
- *Repeatable*: Other scientists should be able to independently replicate or repeat a scientific study and obtain similar, if not identical, results.
- *Scrutinizable*: The procedures used and the inferences derived must withstand critical scrutiny (peer review) by other scientists.

Any branch of inquiry that does not allow the scientific method to test its basic laws or theories cannot be called “science.” For instance, theology (the study of religion) is not science because theological ideas (such as the presence of God) cannot be tested by independent observers using a logical, confirmable, repeatable, and scrutinizable. Similarly, arts, music, literature, humanities, and law are also not considered science, even though they are creative and worthwhile endeavors in their own right.

The scientific method, as applied to social sciences, includes a variety of research approaches, tools, and techniques, for collecting and analyzing qualitative or quantitative data. These methods include laboratory experiments, field surveys, case research, ethnographic research, action research, and so forth. Much of this book is devoted to learning about these different methods. However, recognize that the scientific method operates primarily at the empirical level of research, i.e., how to make observations and analyze these observations. Very little of this method is directly pertinent to the theoretical level, which is really the more challenging part of scientific research.

Types of Scientific Research

Depending on the purpose of research, scientific research projects can be grouped into three types: exploratory, descriptive, and explanatory. **Exploratory research** is often conducted in new areas of inquiry, where the goals of the research are: (1) to scope out the magnitude or extent of a particular phenomenon, problem, or behavior, (2) to generate some initial ideas (or “hunches”) about that phenomenon, or (3) to test the feasibility of undertaking a more extensive study regarding that phenomenon. For instance, if the citizens of a country are generally dissatisfied with governmental policies regarding during an economic recession,