Chapter 3
Logical and Epistemological Norms in Scientific Theory Construction

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The article is concerned with theory construction in both natural and social sciences and the issues relating to such efforts. It provides a historical perspective and debates relating to the nature of theories – "concrete," "middle range," and "abstract" or "grand" – and the logical (deductive and inductive) and epistemological norms (empirical and rationalistic) involved with them. The article highlights an alternative mode of theory construction in the social sciences in contrast with the formal, abstract, grand theories so common in the natural sciences. It argues that this alternative is characterized by *grounded contextualist epistemology*, *causal generalizations*, and *local realism*. Finally, the article provides two good illustrations of what counts as *local contextualist epistemology* and *causal generalizations* in theory construction in the social sciences from the works of Amartya Sen and M.N. Srinivas.

3.1 Introduction

Since the formative period of science in the antiquity, the logic of induction and deduction and the role they play in formulating scientific theories have been the concern for both the practicing scientists and the philosophers of science. It is commonly believed that science (and specifically a scientific theory) does not consist of discrete and random collection of factual statements, but comprises a network of both empirical and theoretical, particular and general, and observational and law statements in a coherent structure and framework. The role of logic in science, especially the job of the construction of scientific theories, essentially relates to spelling out the nature of these connections andrelationships among the

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various types of statements in this network, explaining what entitles the scientists to move from one type of statement to another or justifying on what basis they do so.

The two logics of induction and deduction have bearing also on the relationship between science and experience and foundation of scientific knowledge (the epistemology of science). For traditional epistemology or theory of knowledge, the question of finding *the method(s)* of arriving at acceptable scientific knowledge (or for that matter any knowledge) is interwoven with the issues relating to the basis of *generation or genesis* and *justification* of scientific knowledge, i.e., the issues of genesis and justification are not thought to be independent. History of science reveals that logic, epistemology, and science, especially at the time of the scientific breakthroughs in the form of production and defense of new scientific knowledge, have a close and intimate relationship.

3.1.1 Science: Scientific Method(s) and Logical and Epistemic Norms

In all ages science was considered as one of the paradigm examples of a successful logical and epistemic enterprise; hence, the method(s) science followed in achieving knowledge was thought to be indicative of the very nature of knowledge.[1]

Sciences in the antiquity (such as astronomy, cosmology, mathematics, medicine, biology) developed in tandem with the concern for explicating the nature of "scientific method(s),"[2] i.e., the contention that by using these method(s), science is interested in accurately describing (with the help of mathematics) what we observe or claiming to know how things really are.[3]

During the formative period of classical physics, epistemologists, such as Locke, Herschel, Whewell, and Kant, took scientific knowledge as a paradigm of epistemic enterprise and looked upon themselves as crusaders (or according to Locke, assumed the role of "under laborer") for vindicating the cause of the new knowledge and epistemic claims that were being made by the scientists of their time, especially Newton. Their job as epistemologists consisted in describing the processes and the logic through which this paradigmatic knowledge is acquired and spelling out the norms appropriate for this knowledge.[4]

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[1] Suppe (1977).

[2] Losee (1972), p. 6, Jones (1952), Arnold(1974).

[3] The detailed study of the Babylonian mathematical astronomy can be found in (1) Neugebauer (1957, pp. 105–113). For Egyptian mathematics and astronomy, see Chap. IV, pp. 77–96; for Babylonian mathematics, see Chap. II, pp. 25–70; for astronomy, see Chap. V, pp. 97–144. (2) Neugebauer (1975). For Babylonian astronomy, see Pt. I, Bk. II, pp. 347–555; for Egyptian astronomy, see Pt. II, Bk. III, pp. 559–70.

[4] Locke (1968).

At the turn of this century, when the modern physics was being shaped, logical positivists too felt the necessity of articulating a new paradigm of scientific knowledge and accepted the goal of providing and justifying an account of the nature of scientific enterprise. In this endeavor, the logical positivists pursued with messianic fervor the search for the epistemic norms that would avoid the pitfalls of metaphysical traps in which science, according to them, could be enmeshed, particularly while asserting regularities of nature by invoking entities, which are not directly observable, such as "atom," "electrical field," "molecule," etc. The logical positivists fashioned their account of science on logic and epistemic norms that were solely empirical, exact, quantitative, logical, universal, and objective and found that the social sciences did not measure up to such standards of scientific adequacy.

3.1.2 Logical and Epistemic Norms in the Social Sciences

This alleged difference between natural and social sciences did raise a new set of epistemological and methodological questions concerning the character and possibility of knowledge of social phenomena. The comparison led to a close examination of the main epistemological themes, viz., the foundational and axiomatic systemic models, logic of confirmation and explanation, epistemological status of scientific laws and accidental generalizations, and nature and structure of scientific theory. By focusing directly on these logical and epistemological themes, one gets at the heart of the many different but related issues and questions in the social sciences: the issue of objectivity and causality; the issue of social ontology and realism, naturalism, reductionism, and pluralism; the foundational questions concerning the nature of rationality, self-interest, and preference; and the moral questions concerning welfare, justice, equality, and freedom, which are of abiding significance to social scientists in general and economists in particular. Thus, logic and epistemology indeed play a pivotal role in any scientific endeavor.

3.2 Logics of Induction and Deduction, Epistemology, and Goals of Science

The logics of induction and deduction evolved alongside the two dominant epistemological views of empiricism and rationalism. Both the logics and the associated epistemological views are directly linked with the *nature* and *goal of science*.

Kant in *Metaphysical Foundations of Modern Science* and *Critique of Pure Reason* claimed that his main concern was to explain how *synthetic a priori* judgments are possible in science and mathematics.

3.2.1 Two Logics Defined: Aristotle's Definitions

Till the advent of mathematical logic, there was a widespread view espoused by Kant that Aristotle had discovered all there was to know about logic. Indeed, Aristotle was first to systematically develop logic and define the inductive and deductive arguments.

3.2.2 Inductive Logic

For Aristotle, induction (*epagôgê*) is a cognitive process that moves from particulars to their generalizations, which is the basis of knowledge of the indemonstrable *first principles of sciences* (*Posterior Analytics*).

An *inductive argument* is an argument in which it is thought that the premises provide reasons supporting the *probable* truth of the conclusion. In an inductive argument, the premises are intended only to be so strong that if they are true, then it is *unlikely* that the conclusion is false.

The great intuition Aristotle had was that deduction in natural sciences rests upon prior induction. The universal general premise of a deductive argument is obtained not only through our contacts with the physical world, but because of our ability to grasp the *essential property* the particulars share in common. For Aristotle, essential properties are those without which an object would not be what it is and enable us to categorize an individual object as belonging to a class. So, according to Aristotle, our knowledge of generalization (*noûs*) depends on apprehending or grasping the essences (*archai*).

Aristotle made a distinction between enumerative induction and (intuitive) induction based on *essences*. Enumerative induction amounts to establishing a universal proposition or making a generalization by an exhaustive or complete enumeration of all the instances and ensuring that each satisfies a given property, e.g.,

All observed A's are B's
Therefore, all A's are B's

The more significant generalizations are based on (*intuitive*) *induction* arrived at on the basis of *essences*. Aristotle believed that human beings alone have the ability to acquire *noûs* by apprehending or grasping *archai* through their contacts with individual objects of the physical world.

3.2.3 Deductive Logic

According to Aristotle "a deduction is speech (*logos*) in which, certain things having been supposed, something different from those supposed results of necessity because of their being so."[5] Each of the "things supposed" is a *premise* (*protasis*) of the argument, and what "results of necessity" is the *conclusion* (*sumperasma*).

The most important claim made by this definition relates to the notion of "resulting of necessity" (*ex anankês sumbainein*). This corresponds to the notion of "logical consequence." In a deductive argument, the premises are intended to provide support for the conclusion that is so strong that if the premises are true, it would be *impossible* for the conclusion to be false.

Aristotle's *theory of syllogism* is the first and most comprehensive study of a class of *valid* deductive arguments based entirely on their *structure* or *form* (represented in terms of their "figure" and "mood") and not on their *content* or what these arguments are about.

3.3 Concrete Science: Pure Empiricism, (Phenomenal) Generalizations, and Prediction

The evolution of science in the antiquity – particularly generalization based on accurate observation in sciences, such as astronomy, cosmology, science of motion, and biology – may provide us with insights leading to the contrast between the "concrete" and the "abstract" science.[6] The contributions in astronomy by the Egyptian (c. 2000–500 B.C.) and the Babylonians (c. 1800–150 B.C.) characterize what may be called "concrete science," which is mainly observational and computational in nature and was driven by practical problems.

Generalizations made in these sciences are founded on systematization of data by specifying the relationship between "directly observable" and "explaining" observable phenomena in terms of other observable phenomena but never stepping out of the domain of concrete or observables. The generalizations thus arrived at in concrete science may be called *phenomenal generalizations*,[7] which are derived from the features of the phenomena being observed and investigated. The generalizations never assume any underlying (causal) structure.

The development of the "mathematical" astronomy[8] in these civilizations was dependent on the contrivance of many early astronomical instruments facilitating naked-eye observation (e.g., gnomons, sundials, etc.) and computational techniques by developing relevant mathematics (e.g., number system, spherical geometry, etc.). These aids enabled the early astronomers to make meticulous observation and record them motivated by the desire to solve practical concrete problems they were faced with.

[5] *Prior Analytics* I.2, 24b18-20.

[6] Gupta (1989), Freund (1968), Caneva (1978).

[7] Cartwright (1983, 1989), Little (1993).

[8] Neugebauer (1957, pp. 105–113; 1975), *op. cit.*

3.3.1 A Case Study: The Babylonian Observational Astronomy and (Phenomenal) Generalizations

The practical problem the Babylonian astronomers set out to solve exhibited their remarkable command over arithmetical techniques leading to *(phenomenal) generalizations*, which enabled them to develop calendar and *forecast* many natural events (e.g., the first visibility of the new moon, lunar eclipses, floods, tides, etc.) with remarkable accuracy. However, they achieved all these without having or never formulating any idea about the physical nature of the system of the heavenly bodies.

Babylonian civilization is often known as "calendar civilization." The demands of trade and commerce, religious rites, and astronomical prediction led the Babylonian to develop calendar. The Babylonians devised a lunar calendar which defined a month as the interval between the successive sightings of the first crescent of the moon. Hence, the basic problem underlying the Babylonian astronomy was to predict the visibility of the first crescent each month in order to mark the beginning of the month on the basis of this astronomical phenomenon.

3.3.2 The Problems Faced by the Babylonian Observational Astronomers

O. Neugebauer[9] shows how the Babylonians came to look upon the "first visibility of the crescent" as a complicated periodic phenomenon. The *observational astronomy* of the Babylonians recognized this problem as highly complicated because it was dependent on several other phenomena: the *conjunction* of the sun and the moon just preceding the first visibility, the so-called elongation between the sun and the moon (which increases about 12°per day. In fact, the daily elongation might vary between 10°and 14°, bringing to light the problem involved in detailed knowledge of the variation of both solar and lunar velocities), the *seasonal variation of the angles between the ecliptic* and *horizon* also effecting the visibility of the new moon (the number of days from one new moon to the next is not always the same – sometimes it is 29 days and other times it is 30 days; hence, it is difficult to work out beforehand the point of the first visibility since it is hard to foretell whether any given month would be 29 or 30 days in duration), and *the problem of keeping the lunar calendar in step with the annual cycle of seasons*, i.e., the apparent movement of the sun.

[9]Neugebauer (1957, pp. 105–113).

3.3.3 *Solution: An Example of (Phenomenal) Generalizations*

The Babylonians devised an arithmetical procedure for making astronomical prediction and computation. The table (given in the Appendix 1) shows the monthly conjunction of the sun and the moon (this table is a direct transcription of a cuneiform tablet referring to the year 133–132 B.C.).

According to Neugebauer, the arithmetical technique of the Babylonians consisted of obtaining over-all averages for the main periods of astronomical phenomena. These averages then were improved by occasional individual observations. At the same time, short-range predictions of phenomena could be made on the basis of a series of observations immediately preceding the event. Once the Babylonians had at their disposal extensive and accurate data, they analyzed them (as men who prepare tide table or economists working on "time series" at present times would do) to look for recurring cycles. Having detected a cycle, they observed deviations from the average and saw whether there was any cycle to be found there. Finding an average cycle in these deviations, they next examined the departures from the fresh average and so on. By taking the process far enough, it was possible for the Babylonians to solve the practical problems they set out with and to predict not only when the new moon would be visible but also whether a particular opposition between the sun and moon would result in a lunar eclipse or when the retrogression of planets would take place.

3.4 Abstract Science: Rationalism and Deductivism – The Platonic-Pythagorean-Euclidean Tradition

The shift from the pure "empirical" or concrete science to the anti-empirical, idealistic, and rationalistic character of science and mathematics was advocated by Eleatic, Platonic-Pythagorean-Euclidean tradition, which spearheaded the use of reductio ad absurdum arguments[10] introduced earlier by Parmenides (fl. 540 B.C.), the most famous of the Eleatic thinkers. Plato (428–348 B.C.) turned away from the study of the world as revealed in sense experience in favor of the abstract world of "ideas" and rational methods.

The distrust of sense experience led to the introduction of the "methods of proofs" thought to be more reliable. Pythagoras (c. 570–c. 540 B.C.) and Euclid (fl. 300 B.C.) developed the logically valid deductive patterns of reasoning by constructing "proofs" for such claims as the irrationality of "$\sqrt{2}$" and the existence

[10]The reductio ad absurdum argument essentially involves a technique of proving a claim or theorem Γ by assuming that "not Γ" is true and then deducing from "not Γ" and the axioms of the system both a statement and its negation. It is clear that if the assumption of "not Γ" entails contradiction where the axioms of the system are taken to be true, then "not Γ" must be given up, and "Γ" must be admitted as true.

of an infinity of prime numbers.[11] Euclid in his *Elements*[12] developed geometry, especially in his first two books, out of an earlier hodgepodge of practical methods of measurement and calculation recipes. These were finally brought together under a single set of axioms by Euclid in his *Elements*, when he built a "deductive structure"[13] in his axiomatic system.

Euclid did not rely on experience and observation and used exclusively rational arguments, such as reductio ad absurdum and the *method of exhaustion*[14] (mainly used the latter in Books XI and XII to develop solid geometry), in order to justify and establish his theorems, conclusions, or claims. Euclid's 13 books, constituting the *Elements*, not only cover geometry (plane rectilineal geometry, circle and regular polygons) but also theory of proportions and magnitudes, arithmetic, irrational lines, solid geometry, and regular polyhedral, all in a deductive structure in the axiomatic form.

3.4.1 Norm of Science as an Axiomatic System with Deductive Structure

Following Euclid, Archimedes (287–212 B.C.) was the first to cast an empirical science in the axiomatic mold. Since Euclid and Archimedes, it was expected that empirical science must be an axiomatic deductive system of statements comprising axioms, definitions, and theorems organized in such a manner so that the truth of the theorems follows from the assumed truth of the axioms. Archimedes went on to prove from his axioms on the lever that two unequal weights balance at distances from the fulcrum that are inversely proportional to their weights.

Even during the Renaissance, the "new" science of Galileo (1564–1642) and his treatment of "local motions" (freely falling bodies and projectile motions) in his *Dialogues Concerning Two New Sciences Pertaining to Mechanics and Local Motion*[15] and mechanics of Newton (1642–1727) in his *Philosophiae Naturalis Principia Mathematica* (*Mathematical Principles of Natural Philosophy*)[16] followed the axiomatic method (although in his *Optics* Newton used the inductive method of analysis, but gave it up in his *Principia*).

[11] Szabó (1978), Hardy (1940).

[12] Heath (1861–1940, 1956).

[13] Mueller (1981/2006).

[14] The *method of exhaustion* consists of showing that each possible contrary of a theorem Γ has consequences that are inconsistent with the axioms of the system.

[15] Galileo (1638).

[16] Newton (1729).

3.4.2 Plato's Thesis of "Saving the Appearance"

"Abstract science" consists of speculative, theoretical activity yielding ideas, concepts, axioms of theories and models, and explanatory structures, where knowledge claims and explanations are evaluated in terms of deducing consequences, which corresponds to finding answers to such questions as: "How or why do things happen?" "What are the grounds that determine their occurrence?"

Stephen Toulmin, in his *Foresight and Understanding*,[17] has criticized the predictivist thesis (espoused by concrete science). Prediction or forecasting, according to Toulmin, "is a craft or technology, an application of science rather than the kernel of science itself." On the other hand, Toulmin claims that the function of science is to build up systems of ideas about nature which has some legitimate claim to "reality." For Toulmin, these systems of ideas provide explanatory techniques which not only must be consistent with data but also must be acceptable, for the time being at any rate, as "absolute" and "pleasing to the mind." Moreover, Toulmin says that although scientific theories inter alia are used to predict, their main function, however, is to provide explanations of recognized regularities and explain away anomalies and irregularities in observation.

Some of the anomalies and irregularities in *apparent* motion that were discerned by the ancient *observational* astronomers had to do with the *retrograde* motion, i.e., the motion in a loop of the planets, nonuniform motion of the sun, and irregularities in the motion of the moon, as opposed to the strictly uniform and circular motion expected of all celestial bodies. Plato, who is searching questions that dominated the subsequent astronomical inquiry, is said to have asked:

> What are the uniform and orderly movements by the *assumption* of which the apparent movements of the planets can be accounted for?

The Greek (theoretical) astronomers used three geometrical figures to "model" the observed motions of celestial bodies. The models accounted for the anomalies and irregularities at the same time claiming that the "real" motion described in terms of the these geometrical figures remains strictly uniform and circular. The three geometrical figures that were used for modeling are the deferent and epicycle system (by Claudius Ptolemy to explain the *retrograde* motion of the planets) and the eccentric and the equant circles.

"Abstract science" construes scientific models and theories, such as astronomical theories, as devices for "*saving the appearance*." This view, having a lineage from Geminus (first century B.C.), Plato, Pythagoras, and Ptolemy (c. 100–c. 178 A.D.) and attributed to Copernicus (1473–1543), maintains that scientific theories are mere hypotheses, without any claim to truth, superimposing mathematical relations on phenomena in order to "save the appearance," i.e., to remove the discrepancies and anomalies in observation and making them coherent. It is opposed by *realism*,

[17]Toulmin (1961).

upheld vociferously by Galileo (1564–1642), who maintained that scientific theories must not be viewed as mere computational devices to "save the appearance," since they make claims to *physical truth*.

3.5 Marriage of Concrete and Abstract Science

History of science does not support the conception of theory that differentiates abstract science from the science of the concrete to the exclusion of each other. The abstract science invariably reaches beyond empirical co-occurrence to postulate a representation or structure for the phenomena under investigation, one which *accounts for* the co-occurrence and potentially for other aspects of the phenomena not yet observed. Further, scientific theory, according to abstract science, is not an economic presentation of accumulated propositions claimed as "known." Rather, it goes beyond mere logical organization of given facts in *reinterpreting our experience* in terms of fresh concepts, methods of representation, explanatory procedures, paradigms or ideals of natural order. A theory is intended not as a description of what one already knows but as a hypothesis: something that goes beyond the evidence by introducing a *postulated physical structure* that could provide an inferential or causal account of the data to be explained.

3.5.1 Alleged Incongruence Between Deduction and Induction: A Critical Examination

There is a widespread view that the notion of "deduction" founded on rationalistic epistemology is fundamentally and essentially disparate or incongruent to induction. Moreover, it is argued that unlike deduction, induction cannot be justified as a legitimate form of inference[18] nor could induction be regarded as the characteristic method for scientific investigation.[19]

3.5.2 "Mixed Method" in Geometry

The view stated in 5.1 is countered by those who maintain that deduction and induction are more intimately related than is presently common,[20] and in spite of the overwhelming emphasis on deductive structure of science, induction, "probability theory, and statistical inference" now emerge as better foundations for scientific

[18] Hume (1739/1888).

[19] Popper (1963a, b, 1968).

[20] Beth (1967).

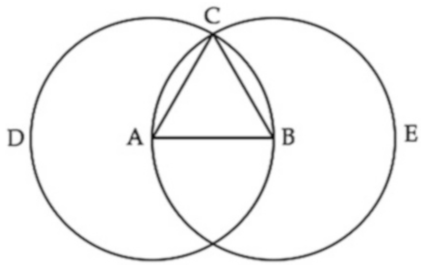
models.[21] Hence, it is necessary to reconceptualize induction in a different way and in a more "favorable light."[22] Euclidean geometry can give us a clue.

3.5.3 Close Relationship Between Deduction and Induction: Geometrical Generalization

An analysis of the deductive structure of proofs in the axiomatic framework of Euclidean geometry will show that *induction is inbuilt* in the Euclidean deductive proofs. In other words, the passage from a particular to a generalization is inherent in all deductive proofs in the Euclidean system.

Consider the structure of the proof of Proposition 1, Book I, of the *Elements* consisting of the following parts:

Enunciation
(*protasis*) On a given finite straight line to construct an equilateral triangle.



Setting-out
(*ekthesis*) Let AB be the given finite straight line.

Specification
(*diorismos*) Thus, it is required to construct an equilateral triangle on the straight line AB.

Construction
(*kataskeuē*) With center A and distance AB, let the circle BCD be drawn; again, with center B and distance BA, let the circle ACE be drawn; and from the point C, at which the circles cut one another, to the points A and B, let the straight lines CA and CB be joined.

[21] Mumford (1999).

[22] Macnamara (1991, pp. 21–48).

Proof (in modern sense)	
(Apodeixis)	1. Since the point A is the center of the circle CDB, AC is equal to AB [by Def. 15]
	2. Again, since the point B is the center of the circle CAE, BC is equal to BA [by Def. 15]
	3. But it was shown that CA is equal to AB (restatement of 1)
	4. Therefore, each of the straight lines CA and CB is equal to AB [from lines 2 and 3]
	5. And things which are equal to the same thing are also equal to one another; therefore, CA is also equal to CB [by CN 1]
	6. Therefore, the three straight lines CA, AB, BC are equal to one another [by CN 1]

Conclusion
(sumperasma) Therefore, the triangle ABC is equilateral; and it has been constructed on the given finite straight line AB, which was required to be done (Q.E.F.).

The six parts of the Euclidean proof of Proposition 1, Book I, show that geometrical proof, according to Euclid, does not rest merely on part 5, i.e., apodeixis (proof) [which essentially is similar to our familiar concept of "proof," viz., a sequence of steps each justified by an appeal to either Euclidean definitions or common notions (or other initially given assumptions of Euclid) or a step following from the previous line(s) already justified].

If the apodeixis (proof) exists, then why does Euclid need the other components of his demonstration, especially enunciation (*protasis*), setting-out (*ekthesis*), specification (*diorismos*), and then a summary in conclusion (sumperasma)? This is because, as Beth points out, although the entire demonstration – from *protasis* to *sumperasma* – is about a *specific* geometrical figure, in this case it is about a *specific* line AB; the conclusion being arrived at, however, applies to *all* lines. If the *apodeixis* concerns only to a specific line chosen, then the entire exercise of doing geometry is pointless.

3.5.4 The Condition Legitimizing Euclid's Passage from Particular to the Universal Generalization

The important issue, which needs to be brought out here, is: what is the condition that legitimizes Euclid's passage from particular to the universal generalization? The answer has to do with the fact that universal generalization is permitted only when *no special assumptions* are made about the particulars in terms of which the proof was carried out. The axiomatic system of geometry must ensure that *no properties* of the geometrical figure under consideration are being used in the entire geometrical proof.

The violation of this condition did take place owing to the common practice, since Euclid, of the use of figures as part of proofs in geometry and resultant smuggling in unstated assumptions relating to their properties (as documented by Lakatos[23] in the case of Descartes-Euler conjecture on polyhedra). This was the main justification given for *formalizing* mathematics (geometry and arithmetic), as was done by Hilbert (1862–1943) in formalizing Euclidean geometry in 1903, completely banning the use of geometrical figures and permitting symbols to represent them only under interpretation.[24] The rule of universal generalization in logic essentially performs induction by using variables and allowing them to range over *arbitrary* objects or individuals without invoking any of their properties. (However, there is debate whether generalizations in geometry and the rule of inference, called UG, are similar.[25])

3.6 "Mixed Method" in the Natural Sciences

It is believed that generalizations engendered by geometry in its axiomatic form are no different from those in the empirical sciences. The articulation of the view combining inductive and deductive approaches to scientific knowledge can be traced back to Aristotle. In his study of local motion exhibited by, for example, freely falling bodies, Aristotle combines the inductive-deductive method.

3.6.1 Aristotle's Notion of Science: Demonstrative Science

For Aristotle, scientific knowledge (*epistêmonikon*) involves the processes of both induction and deduction. Deduction in the sciences rests on induction. Unlike many thinkers even in contemporary times (some denouncing and censuring induction), Aristotle maintained that induction and deduction in science form a single system.

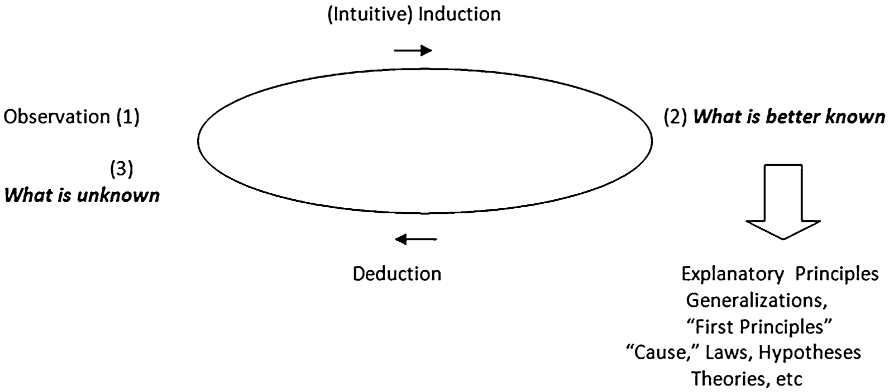
With this distinction between empirical and rational abstract, speculation was forced. Scientists relate the visible changes in nature to the permanent principles underlying them ("*logos*"). There is a prevailing conviction that nature functions, not willfully but "rationally," i.e., according to some principle. The scientists' essential task is to get an intellectual grasp of the character of natural order, showing in this way why the events had to happen as they did. The "method of hypothesis" or postulational method is regarded as one of the main ways the (scientific) knowledge of this natural order can be articulated.

[23]Lakatos (1976).

[24]Hilbert (1902).

[25]Fine (1985), Stoll (1961), Macnamara (1991, pp. 26–27).

Aristotle claimed that *science is demonstrative* (*apodeixis*), i.e., deducing "what is unknown" from "what is better known." According to Aristotle, providing (epistemic) explanation and justification of what is unknown amounts to deducing the unknown from its cause, i.e., giving some sort of causal explanation based on generalizations attained through the process of "intuitive" induction. Aristotle's inductive-deductive method looks like this[26]:



3.6.2 Congruence Between Deduction and Induction in Aristotle's Science

Using the *inductive-deductive method*, Aristotle developed his *science of motion*, starting with four *doctrines*, four *first principles*, and the *laws of motion* (based on his claim to establish generalizations founded on (intuitive) *induction* arrived at on the basis of his notion of *essences*), and then derived *deductively* empirical consequences from them (see Appendix 3.2).

In the history of epistemology, one observes a tension between access to reality through empirical facts (empiricism) and through predictive mathematical laws (rationalism). Aristotle saw this tension while justifying any particular conceptual framework or theoretical paradigm. For him the tension was between (1) the abstract ideal character of mathematics appropriate to describe the underlying ideal structure that forms the basis of our understanding of the observed world and (2) the possibility of its (i.e., mathematical modeling or idealization) grasping the complex real world because of the alleged inappropriateness and possible lack of "fit" between the ideal and the real. However, he resolved it by introducing the concept of *mixed science*.

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[26] Adapted from Losee (1972, p. 6).

For example, according to Aristotle, arithmetic is useful since it signifies the quantitative characteristics embodied in matter or the real world, the *numerical* dimension of sensible object. Similarly, Aristotle believed that geometry is necessary for a proper understanding of such natural phenomena as an eclipse or a rainbow.

The reason for this is that the explanation of the occurrence of such natural phenomena would be given in terms of certain physico-mathematical properties (e.g., a certain spatial configuration between the sun, the moon, the spherical raindrops, and the observer, the rectilinear path of the light ray, etc.) that exhibit the closeness or fit between nature and geometrical idealization. Such closeness or fit was thought to be the basis for the so-called mixed sciences, such as astronomy, optics, mechanics, and harmonics, in which Aristotle took the use of mathematics for granted. In the Middle Ages and the Renaissance, the followers of Aristotle, e.g., Robert Grosseteste, Albert the Great, and Thomas Aquinas, endorsed the "mixed sciences."

3.6.3 The Method of Hypothesis

In due course, the task of science consisted of relating the "phenomena" (or even departure from the regular order of things) to paradigms (i.e., an "exemplar" or "ideals of natural order"). A community of scientist proposes or assumes that certain behavior patterns are natural and expected; the expected does not require explanation – only the unexpected does. The job of a scientific theory, then, is to specify these expected patterns of behavior and to explain deviations from them. All behavior within a given domain, then, is to be accounted for either by its conformity to expectations or by explaining its deviations from expectations. However, this presupposes that a community of scientist agrees upon certain natural course of events, paradigms, or "ideals of natural order," e.g., the law of inertia, the principle of rectilinear propagation of light, etc.

It is this conception, a scientific theory that does not differentiate abstract science from the science of the concrete to the exclusion of each other. Moreover, a scientific theory reaches beyond empirical co-occurrence to postulate a representation or structure for the phenomena under investigation, one which accounts for the co-occurrence as well as the potential explanation for other aspects of the phenomena not yet observed. Further, scientific theory is not an economic presentation of accumulated propositions claimed as "known." Rather, it goes beyond mere logical organization of given facts in reinterpreting our experience in terms of fresh concepts, methods of representation, explanatory procedures, paradigms, or ideals of natural order. A theory is intended not as a description of what one already knows but as a *hypothesis*, something that goes beyond the evidence by introducing a *postulated physical structure* that could provide an inferential or causal account of the data to be explained.

Thus, it became a norm that a completed science will have two components:

(a) Observational laws, e.g., in Newton's mechanics, Galileo's laws of freely falling bodies and projectile motion, as well as Kepler's three laws of planetary motion
(b) The axioms or hypotheses from which the observational laws could be derived and thereby explaining them, e.g., the three laws of motion as axioms of Newton's theory of mechanics

Another example of this postulational hypothetical structure of science accounting for and explaining the observational laws can be found in kinetic theory of gases (see Appendix 3).

3.7 Axiomatic Systemic Notion of Theory

The other epistemological view, known as the received view of theory, maintains that the basic principles are materially true a priori and constitute the starting point of the axiomatic structure of a scientific theory, often called "the *axiomatic systemic* notion of theory." An outline of this has been given in Sects. 3.5 and 3.6.

3.7.1 Axiomatic Systemic Model in the Social Science

The received view on modern mathematical exact sciences supports a lofty vision of a world completely ordered by a single elegant theory. One of the most cherished goals of the logical positivists was a unified science bound by a common rationale. It was claimed to have the structure of a pyramid with a system of few simple, elegant, abstract, all-embracing, general, universal axioms on the top and a vast array of relatively less abstract but specific domains with their observational laws below it.

Mill in his essay *On the Definition and Method of Political Economy*[27] draws an analogy between *economics and geometry*.

The rationality assumption in social sciences turns some part of social life into an abstract a priori game of skills. Hobbes in Leviathan also endorses a similar comparison by comparing the rules of social life with the rules that enable us to do arithmetic or geometry.[28]

Lionel Robbins in his *An Essay on the Nature and Significance of Economic Science* (1932)[29] draws an analogy between *economics and mechanics.* There are reasons for preferring mechanics, if we have to seek analogies, since it allows phenomena as countervailing causes, whereas it is hard to envisage the presence of

[27] Mill et al. (1963).

[28] Hobbes, Leviathan (1651).

[29] Robbins (1932).

causes in geometry. Thus, Robbins claims that economics is a species of mechanics and that laws in economics are "necessities to which human action is subject."

The usual textbook introduction tends to create an impression that the basis of economics lies in approximate truths about consumer and producer behavior together with some acknowledgement that different assumptions would produce different theories.

Generally, theory-governed explanations are a priori. Many of these theories amount to the blueprint of the underlying mechanism we want to study, manifested in the behavior of the phenomena. The underlying mechanism, say in classical mechanics or kinetic theory of gases, is often formulated in terms of certain assumptions or axioms.

Milton Friedman in his *The Methodology of Positive Economics* (1953)[30] fashions any sound economic theory into a "logical language" and "a body of substantive hypotheses." The former, according to him, is a "set of tautologies" and "its function is to act as a filling system." The latter is "designed to abstract essential features of a complex reality."

Friedman raises the question: "Can a hypothesis be tested by the realism of its assumptions?" His answer is that the "realism of assumptions" is irrelevant to the assessment of a theory. For him the only test of the theory is its success with prediction; realism is not the criterion. However, he does not support the standard instrumentalist position.

Ludwig von Mises (1960, 1962)[31] attempted to construct one unique great axiomatic economic theory with complete and deductively closed set of precise statements into which all our knowledge relating to diverse intelligible phenomena can be fitted. For example, Ludwig von Mises argued that all statements of economic theory followed deductively from an axiom that he held to be materially true a priori, the so-called basic concept of action and its categorical conditions. He claimed that all the theorems of economics can be derived from these axioms. Thus, according to von Mises, the empirical testing of economic theory becomes totally superfluous. At best we can check the deductive reasoning to make sure that the conclusions do in fact follow necessarily from the axioms.

The recent example of the use of *axiomatic systemic model* in social sciences can be seen in "social choice theory," mainly authored by economists and political scientists. The theory aims at modeling the mechanism of collective decision making.[32] Logic has also been found to be useful in formally specifying and verifying the properties of procedures of social choice by developing *social software*.[33] (For a comprehensive coverage of this important development, refer to *Logic and Social Choice Theory*.)[34]

[30] Friedman (1953).

[31] von Mises (1960, 1962).

[32] Arrow (1951, 1963), Sen (1986, 1970, n.d.).

[33] Parikh (2002).

[34] Endris (2011).

3.7.2 Construction of "Scientific" Sociological Theories: "Grand" and "Middle-Range" Theories

Talcott Parsons tried to develop a general theory of society in his *The Social System* (1951).[35] Parsons attempted to present a general theory of society or "social system theory," influenced by "systems theory" and "cybernetics" and adopting their basic ideas and concepts to the realm of sociology and social sciences, such as "feedback," "latent function," "pattern maintenance function," "equilibrium," etc. The Parsonian paradigm was meant to generate a "grand" inclusive theory and the scientific laws of society similar to the natural sciences.

In contrast with "grand" theories, the idea of "middle-range" theories in sociology was mooted by a group of sociologists in the 1950s, such as Robert Merton (1949/1957/1968),[36] Hans Zetterberg (1954/1963/1965),[37] Llewellyn Gross (1959),[38] and others. Zetterberg said: "In physics, the theory of relativity and the quantum theory are inclusive theories in terms of which most laws of physics can be explained. The goal of the scientific enterprise is to know such a theory." However, Merton acknowledging the present limitations of the "theoretical paucity" in sociology asserted that "between twentieth century physics and twentieth century sociology stand billions of man-hours of sustained, disciplined and cumulative research. Perhaps sociology is not yet ready for its Einstein because it has not yet found its Kepler – to say nothing of its Newton, Laplace, Gibbs, Maxwell or Plank."

3.7.3 "Dust-Bowl Empiricism" or "Barefoot Empiricism" in the Social Sciences

Naïve or simple empiricism and positivistic tradition or what has been characterized as "dust-bowl empiricism" or "barefoot empiricism" derives its character from the insistence on the *epistemic primacy of observation* and the rejection of a priori theorizing as an epistemic source of explanation.

The methods codified by the advocates of this approach in social scientific theorizing, more commonly known as verificational approach, emphasize on data collection, statistical analysis, hypothesis formulation, and testing them against empirical facts. This approach raised the hope (expressed by, e.g., Lipset[39]) of a truly "scientific" social science.[40]

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[35] Parsons (1951).

[36] Merton (1949/1957/1968).

[37] Zetterberg (1954/1963/1965).

[38] Gross (1959).

[39] Lipset (1994).

[40] Gibbs (1972), Cohen (1980).

3.7.4 Objections to the Empiricist Positivistic Approach

Some of the objections to the epistemic primacy of "dust-bowl" or "barefoot empiricism" are:

(1) Scientific *observation is theory laden*: granting that the objects that are observed and the properties possessed by them are independent of the observer, but what kind of objects they are observed to be and the properties that are observed are ***relative*** to and determined by the observer's theory, belief, prior knowledge, i.e., observer's *conceptual perspective*. Hence, the adherents of two different theories will view the same phenomenon in two different ways. Hanson maintains that Tycho and Kepler would see different things while watching the same dawn.

(2) *Underdetermination of theory by facts*: the *same set of facts may be explained by more than one theory*. What counts as a fact is determined by the *conceptual perspective* associated with a theory.

(3) *The meanings of a term* in a given theory cannot be considered in isolation. Its meaning is derived from being part of a theoretical system. The meaning of any term, say *mass*, common in two different theories, for example, in classical mechanics and special theory of relativity, will not be the same in the two theories as different and incompatible equations about mass hold in the two theories. Hence, the condition of *invariance of meaning* across the theories does not hold, and different theories are noncomparable or *incommensurable*.

(4) *Conceptual relativism*: the incommensurability thesis stated in (iii) implies conceptual *relativism* – the acceptance of one theory over another is relative to a prior commitment to a paradigm or a *conceptual perspective*, rather than to a neutral, objective criteria of evaluation. The *conceptual perspective* analysis not only reduced scientific knowledge to a subjective enterprise, but made it ***relative*** to a sociocultural group.

(5) Since the 1960s, the static positivistic model of scientific knowledge was replaced by the *dynamic model*. This led to a historical approach and an analysis of the actual scientific practices in order to develop an understanding of the principles that govern rational transitions or justifiable change of belief in the growth of scientific knowledge.

(6) Based on detailed historical studies, the view that has emerged is: *there is no uniquely correct methodology of science as* there exists *plurality of methodologies* which are employed for all sorts of reasons.

3.8 The Character of Knowledge of Social Phenomena

Otto Neurath (1935)[41] exhorted us to give up our belief in the "system," one great scientific theory, i.e., a unique, complete, and deductively closed set of precise statements, into which all intelligible phenomena of nature can be fitted. Recently, Nancy Cartwright supported these ideas in her *The Dappled World*,[42] in which she argues that the idea of unified theory that models all situations is a myth since "we live in a dappled world, a world rich in different things, with different natures, behaving in different ways." These differences can be accounted for in terms of the approaches toward understanding of nature typified by their own theoretical concepts, models, experimental and observational techniques, the objects of investigation, which are *characteristic of each domain*.

This prompted a local realistic view of scientific explanation. According to this view, we posit natural mechanisms whose working is responsible for the way the phenomena appear and "laws of nature" get their depth not from the fact that they express something about the essences of things or are based on statistical generalizations but from the fact that similar mechanisms are seen to underpin very different seeming phenomena.

3.8.1 Karl Popper's "Situational Logic"

Popperian pluralism is a form of rationalism or a halfway position in the struggle between rationalism and empiricism. In opposition to psychologism of Freud and interpretative (*verstehen*) methodology of Max Weber, Popper claims that there exists a *purely objective method* in the social sciences, which may well be called *situational logic*. It consists in realizing that an action is *objectively appropriate to a situation*. Popper says:

> The man with certain wishes therefore becomes a man whose situation may be characterized by the fact that he pursues certain objective aims; and a man with certain memories or associations becomes a man whose situation can be characterized by the fact that he is equipped objectively with certain theories or with certain information.[43]

Popper's *Models, instruments, and truth*: *The Rationality Principle in the Social Sciences* is a significant contribution on *practical inference* in which the situation and the actor's decision scheme jointly imply "the thing to do."[44]

[41] Neurath (1983).

[42] Cartwright (1999).

[43] Popper (1963a, b).

[44] Popper (1963a, b, 1970).

3.8.2 Grounded Contextualist Epistemology and Local Realism

The works of Nancy Cartwright (1983, 1989),[45] Arthur Fine (1986, 1996),[46] and Ian Hacking (1983)[47] have shown the futility and sterility of a generic, global epistemic debate on the realism-antirealism and its replacement by a local contextualist epistemology grounded in doing science, getting involved in actual specific issues faced by a given science and taking a natural ontological attitude. Hacking calls this change from global to local epistemology a shift from representing to intervening.

Harold Kincaid (1996)[48] and Nicholas Huggett (2001)[49] claim that this attitude of epistemology in philosophy of science is reflected in downplaying global concerns of representation, correspondence, or truth and explaining the possibility of knowledge in terms of specific models of entities with causal powers under particular circumstances. This is called "localism" or "local realism."

3.8.3 Local Realism and Causal Generalizations: W. Salmon and N. Cartwright

Wesley Salmon (1971)[50] rejects the Humean conception of causation as linked chains of events by attempting to articulate an epistemologically sound theory of continuous causal processes and causal interactions. It reads not so much as an analysis of the term "causality" as a set of instructions for producing a causal explanation of a particular phenomenon or event.

One begins by compiling a list of statistically relevant factors and analyzing the list by a variety of methods. This procedure terminates in the creation of causal models of these statistical relationships and empirical testing to determine which of these models is best supported by the evidence. Salmon insists that an adequate explanation has not been achieved until the fundamental causal mechanisms of a phenomenon have been articulated.

Nancy Cartwright (1983, 1989) also forcefully endorses the idea that regularity or, for that matter, causal explanation of a phenomenon involves identifying the causal processes, *capacities*, and relations that underlie the phenomenon.

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[45] Cartwright (1983, 1999).

[46] Fine (1986, 1996).

[47] Hacking (1983).

[48] Kincaid (1996).

[49] Huggett (2001).

[50] Salmon (1971).

3.8.4 Generalization in Social Sciences: H. Kincaid

It has been argued that social sciences cannot have laws and generalizations (John Searle (1984),[51] P. Churchland (1979)[52]) because it is built around folk psychology that invokes mental states like beliefs, desires, etc., and there can be no laws relating mental states and behavior.

N. Cartwright (1989) and Harold Kincaid (1996) reject these largely a priori arguments against the constraints put on lawlike explanations in the social sciences. They argue that if the constraints of complexity, redescription, and ceteris paribus conditions were cogent, they would succeed in preventing laws in most of natural sciences as well. They defend the possibility and reality of generalizations and well-confirmed laws in the social sciences based on the discovery of causal mechanisms underlying various social processes.

With the help of substantive arguments, Kincaid goes on to demonstrate that in terms of a local contextualist epistemology, it is possible to produce well-confirmed laws according to standard scientific procedures *in certain sections* of social sciences. The laws of market behavior, which are fundamental and common to divergent economic theories – neoclassical, Austrian, and Marxist – are confirmed if the relevant ceteris paribus clauses hold. The laws are *a rise in the price of a good will result in a decrease in quantity demanded*, and *a decline in the supply of a good will result in a rise in price*. Empirical evidences have shown that the relevant ceteris paribus clauses for these laws do hold. Studies by A. Weinstein show that *the preferences are* frequently *transitive*. Based on the empirical work by G. Becker, it is reasonable to believe that even when preferences are not orderly, little deviation from the above laws will result. Claiming that these two laws are not rare jewels in the morass of otherwise *soft* social sciences, Kincaid goes on to extend the same conclusion to the best empirical work on cultural evolution and ecological adaptation in small-scale societies carried out by anthropologists and economists. These works are similar to the scientific work in evolutionary biology and ecology producing lawlike claims, such as *the law of succession*.

3.8.5 Phenomenal Regularities and Causal Realism: D. Little

The reason for caveats and avoiding sweeping claims about well-confirmed laws in social sciences in general prompts Daniel Little (1991, 2003)[53] to assert that the regularities that can be found within social sciences are *phenomenal*, produced by the specifics of the social- and individual-level causal mechanisms and processes.

[51] Searle (1984).

[52] Churchland (1979).

[53] Little (1991, 2003).

The objective of social science is to discover such causal mechanisms, processes, and powers or capacities that derive from agents and institutions and the regularities they produce, instead of looking for lawlike generalizations or providing interpretation of behavior. This view on social explanation aims to give "…a true description of underlying causal factors sufficient to bring about the phenomenon in question." Little calls this view *causal realism*. He says: "…against current anti-positivistic criticisms among social scientists, I will argue for causal realism in social explanation: causal explanation is at the core of much social research, and causal hypotheses depend on appropriate standards of empirical confirmation for their acceptability."

Claiming that the justifications for causal realism are not a priori but based on empirically informed analysis, Little suggests that the philosophy of science and the metaphysics of social causation must be in close proximity to the scientific discipline that is its subject. With reference to the ontology of social causation, Little subscribes to a naturalistic view maintaining that the causal influence that social entities have is through their effects on individual action. Thus, social phenomenon supervenes but is natural since it is the result of the actions and states of human beings, who themselves are natural organisms. However, Little denies that strong lawlike regularities exist at the social level.

Following Nancy Cartwright's distinction, made in her *How the Laws of Physics Lie*, between fundamental and phenomenal laws, Little differentiates between "governing" and "phenomenal" regularities. A law of nature is a paradigm example of governing regularity as the law describes the behavior of a given natural kind (See Appendix 3.4). He denies that social concepts, such as "state," "class," "market economy," "share-cropping land-tenure system," etc., serve to identify social kinds, analogous to natural kinds. They function rather as ideal types or cluster concepts, permitting us to classify a range of diverse phenomena under a single concept.

The phenomenal regularities comprising social concepts are *emergent* inductively discernable patterns that derive from the underlying causal properties of things and mechanisms. Such regularities, however, are not accidental generalizations as they support counterfactuals and qualify as lawlike. Little gives examples of a variety of regularities concerning the state suggested by social scientists: states create entrenched bureaucracies, states maximize revenues, state crises cause revolutions, etc. Although these regularities hold across a number of cases and support counterfactuals, they derive their strength on the basis of the underlying institutional and individual-level circumstances that give rise to the regularities of state behavior mentioned above.

In his *Varieties of Social Explanation* (1991), Little explains the idea of causal ascription in terms of attributing causal mechanism and causal power: to assert that A causes B is to assert that A in the context of *typical causal fields* brings about B (or increases the probability of the occurrence of B). This concept is further elaborated in terms of the idea of a causal chain: A causes B just in case there are structured circumstances of agency of the individuals at the microlevel making up social institution and representing the causal mechanisms that link the occurrence of A to the occurrences of B.

The causal power of a social institution operates through incentives, opportunities, empowerments, information preference formation, etc., that are embodied in a social structure affecting the actions of the individuals. A "social institution," unlike "brute facts," has a logic and is the result of a set of constitutional rules, which defines it. This idea of a "logic of institution" attempts to capture the notion that a social entity has an entrenched set of incentives and constraints on individual actions that follow from these defining constitutional rules. By altering incentives, preferences, and beliefs, the logic of social institutions has effects on the intentionality of individual behavior, which in turn produce aggregate social outcome. The concern of the social scientist is to provide explanations of social phenomena by laying bare this logic and the causal mechanism on which it is grounded.

Little illustrates how social entities have causal influence on agents in terms of the structuring of incentives and opportunities for them. For example, it is not a brute fact that transport system and patterns of settlement are highly correlated. The logic of the transport systems as a social institution dictates that it has the causal capacity to influence patterns of settlement: settlements arise and grow at the hubs of the transport system because proximity of the transport system is economically desirable for agents. The regularity that increasing the tariff on imported running shoes leads to an increase in consumption of domestic running shoes can be explained in terms of price sensitivity of the consumers resulting in a shift in consumer behavior.

In the same way, the observation that centralized bureaucratic states have greater capacity to collect revenue from the periphery than decentralized feudal states would require explanations in terms of an account of the causal capacities of these states. Similar accounts need to be given for generalizations such as "low GNP is correlated with high infant mortality" or "political development produces political instability."

Since we cannot expect to find a strong underlying order in the social system (may be because it is a "dappled world"), the regularities in social world, according to Little, are not deterministic and "governing" as they are conditioned by ceteris paribus clauses, incomplete knowledge of causal fields, and other similar problems. Hence, the *predictive capacity* of the social sciences is very *limited*.

Yet for Little, such "phenomenal" regularities pertaining to social domain are lawlike, support counterfactuals, and are grounded on complex causal influences conveyed by microlevel individual agency. This means that macro-level theories, such as rational choice theory, game theory, theory of institutions, collective action theory, systems theory, etc., require microlevel foundations in terms of microeconomics or micro-sociology. The job of such theories is to unravel underlying causal mechanisms that produce phenomenal regularities.

In order to illustrate the work on this genre, I wish to select two substantive examples of social scientists: the works of Amartya Sen and M.N. Srinivas.

3.9 Two Case Studies

3.9.1 Amartya Sen

The work of Amartya Sen and his prolific research contributions in welfare and development economics touch on several key foundational issues in philosophy of social science: (A) methodological issues in philosophy of social science, (B) methodological and ethical issues in social sciences, and (C) issues relating to applied sciences, such as poverty, famine, and gender. I shall try to spell out briefly what I consider to be the main contributions in each one of these areas. This is not an exposition of his technical contributions in economics, but a brief summary of some of Sen's contributions on methodology and philosophical issues in social science.

In (A) methodological issues in social sciences, especially in welfare and development economics, Amartya Sen is mainly concerned with two important problems: (1) the search for an overarching unified theory and (2) the problem of objectivity in the social sciences.

Let me state a few salient points relating to Sen's contributions in methodology of economics and general philosophy of science.

First, the received view on modern mathematical exact sciences supports a lofty vision of a world completely ordered by a single elegant theory. One of the most cherished goals of the logical positivists was a unified science bound by a common rationale. It was claimed to have the structure of a pyramid with a system of few simple, elegant, abstract, all-embracing, general, universal axioms on the top and a vast array of relatively less abstract but specific domains with their observational laws below it.

Serious questions have been raised about this approach and its attempt at unification. A careful analysis of the actual scientific practices at the ground level reveals that there is very little in common in terms of both methodology and content between any two given domains of science. Moreover, as Nancy Cartwright has pointed out, our world is rich in different things, with different natures, behaving in different ways.

Sen arrives at the same conclusion by maintaining that the grand theories or very abstract theoretical assumptions, such as the self-interest assumption (i.e., we act to maximize our own utilities) or the assumption of rational conduct (i.e., certain behavior can be proved to be rational by rational choice theory or game theory) or the concept of "economic man" or the assumption of "perfect foresight" or "perfect competition" or "general equilibrium," are false.[54] For Sen, this amounts to claiming that (a) distinct scientific domains and even within a given domain distinct theories model different situations in the world and are severely restricted in scope and (b) each theory at best can model highly simplified situation and cannot model every situation within its purported domain. Although some of Sen's earliest work dealt

[54] Sen (1977).

with the technical details of some of the macro-level theories, such as rational choice theory, collective choice and game theory, and the critical assessment of their basic assumptions, his main concern was with their microlevel foundations in terms of human agency.

Rather than treating the abstract models as vehicles of truth, he construed the macro-level theories as merely expository devices for understanding the specific socioeconomic structures and causal mechanisms true in a society given in terms of different probability measures appropriate for the quantities appearing in the causal relations. In the work of Sudhir Anand and Ravi Kanbur on Sri Lanka's welfare program, Sen was criticized for not adopting a causal relation that holds among designated quantities across all developing countries. Some of these causal variables are per capita income, technological advance, social welfare expenditure, living standard, and the like. Instead, Sen adopted a hypothesis representing different causal mechanisms for different countries. Cartwright has shown that Sen is right in his approach.

Sen is concerned with the issue that if abstract models contain empirical falsity, how much falsity should be allowed within an empirical theory? In his *Standard of Living*,[55] Sen compares two concepts that are often used as indicators of development: one abstract amenable to accurate measure and mathematical treatment and the other that does not readily admit of such treatment. Sen demonstrates that the two relevant concepts, viz., the concept of gross national income or what he calls the opulence measure and the concept of standard of living defined in terms of a set of functioning and capabilities, are indeed different and therefore cannot be identified. While evaluating the standard of living, one should look at those situations in which one must function, such as health, life expectancy, infant mortality, primary education, shelter, etc. They, however, cannot be aggregated. But its traditional alternative, viz., "national income aggregate," would admit of mathematical treatment but be useless and a false description, say, for devising planning strategies. It would be useless because such data would hide information vital for planning, such as distribution of resources. Moreover, it would be harmful if planning strategies are formulated based entirely on such measures since strategies based exclusively on this information would be quite misleading for the planners.

Second, absence of grand global theories might appear to lead to relativism and lack of objectivity in the social sciences. Sen avoids relativism and lack of objectivity in the social sciences by upholding what he calls "positional objectivity"[56] and the role it plays in selecting scientific data and acquiring scientific knowledge. While addressing issues such as "gender bias" or "cultural relativism," Sen maintains that although observation is unavoidably position based, scientific reasoning need not be based on observation from one specific position only. If under appropriate conditions one fails to see a mirage, it would only demonstrate that there is something wrong with one's vision. However, the explanation of mirage in terms of

[55] Sen (1985).

[56] Sen (1993).

a theory in optics based on refraction of light passing through an atmosphere having an unusual distribution of air density indicates the possibility of a *transpositional perspective*, which takes into account distinct observational positions.

Hence, the issue here is whether economics can produce *transpositional perspective* in its explanation, yet at the same time invoking its local categories. Sen highlights the importance of "internal criticism" in social sciences in order to arrive at the transpositional perspective. For example, a transpositional assessment may necessitate a revision of the received view in gender studies, viz., inferiority of women. In spite of applying diverse categories to the social world, there exists the possibility of discovering an order and the same criteria of credibility and cogent argument. This underlying notion of what is valid or credible *transpositionally* in social science is thought to be the essence of objectivity of social scientific knowledge. This notion of valid scientific knowledge constitutes the hard core, the common ideology in all branches of social science.

(B) On the question of the disjunction between facts and values (or ethical considerations) in the social sciences, one is naturally reminded of Hume's injunction that the normative can never be derived from the descriptive premises, i.e., *ought* not to be deduced from *is.* This led to a serious distancing between economics and ethics. Efforts to keep values out of economics motivated some to endorse what Milton Friedman calls positive economics claiming that it is a purely observational science and consequent states of affairs. However, not all consequences are either of equal importance or desirable. Desirability and the evaluation or prioritizing consequences is dependent upon the values we uphold. Hence, fact-value dichotomy cannot be maintained, and in the last analysis, positive economics is subsumed under normative economics. Moreover, a forceful denial of the rigid distinction between fact and value has come from several philosophers in the recent past, such as Max Black, John Searle, Hilary Putnam, and Sen. Keeping their contributions in mind, it is important to make a distinction between universal naturalism (i.e., the view that all value judgments can be derived from factual premises) and existential naturalism (i.e., values can be derived from factual premises only in certain contexts). It appears that Sen endorses only the latter view. This position, however, requires some analysis.

It is well known that the dominant form of naturalism in ethics is self-interest or utility, and through utilitarian ethics, economics has come to embrace self-interest maximization as the definition of rationality as is evident from the work of Edgeworth, Arrow, Hahn, and Samuelson. Utilitarianism, however, is supported by following theses: welfarism (i.e., the judgment of relative goodness of alternative states of affairs must be exclusively based on, and taken as an increasing function of, the respective collection of individual utilities in these states), sum-ranking (i.e., one collection of individual utilities is at least as good as another if and only if it has at least as large a sum total), and consequentialism (i.e., goodness of a state of affairs has to be judged on the basis of goodness of the consequent state of affairs). There are aspects of utilitarianism, viz., act utilitarianism, which evaluate actions in terms of the consequences.

Sen argues that this consequentialist view, i.e., taking self-interest maximization as the only possibility, could not be an essential part of man's rationality. Hence, Sen considers non-gains maximization as a viable alternative to self-interest maximization. Moreover, preferences in revealed preference theory are quite different from what is actually chosen in a given situation. Finally, the first two theses, viz., welfarism and sum-ranking, cannot deal adequately the issue of *well-being* of a person. Sen shows that since an economic theory requires other relevant concepts, such as justice and liberty, naturalism and utilitarianism have to be jettisoned.

From the ruins of utilitarianism, is it possible to reconstruct a viable form of naturalism and utilitarianism? Sen suggests a viable alternative. Sen's alternative is based on his views on "existential naturalism" (i.e., values can be derived from factual premises only if they are contextualized) and "plural utility" (i.e., a vector view of utility that accepts nonutility considerations also in moral discourse and the possibility of their co-existence).

Sen develops an alternative by falling back on the concept of *well-being* and other associated ethical concepts, such as justice, equality, liberty, freedom, etc. Sen's approach emerges not only out of his pure theory of social choice and critique of the works of many leading moral philosophers and political thinkers, such as Rawls, Nozick, Berlin, etc., but also the constructive possibilities that the new literature in these areas produced based on informational basis of judgments and available statistics for a variety of economic and social appraisals: measuring economic inequality, judging poverty, evaluating projects, analyzing unemployment, famine, assessing gender inequality, investigating the principles and implications of liberty and rights, and so on. On this informational and factual basis, Sen shows how individual well-being can be defined more satisfactorily in terms of "basic capabilities" and not in terms of "primary goods," which Sen dubs as commodity fetishism.

Sen carries out a systematic analysis not only in interdisciplinary research involving epistemological and ethical issues, but implicit in his monumental work are explorations and implications of the conditions of developing countries and characterization of the nature of human agency in terms of a new vocabulary in welfare and development economics, such as well-being, basic capabilities, empowerment, etc., which takes us away from Western utilitarian self-centered concept of welfare and toward democratic and pluralistic norms in organizing society. Sen himself admitted that many of his ideas on human development and human rights were inspired by the teachings of Buddha and Ashoka.

In (C) issues relating to applied sciences, such as poverty, famine, and gender, Sen has been concerned with more practical problems that were totally ignored by the practitioners of mainstream economics. This is an interdisciplinary area in which Sen collaborated with development economists and field scientists.

3.9.2 M.N. Srinivas

M.N. Srinivas was one of the most distinguished Indian sociologists and social anthropologist. He was deeply concerned with methodological issues in these disciplines and wrote on issues relating to the significance of fieldwork, participant observation in social science research, the observer and the observed, and the insider and the outsider in cultural studies. Many of these methodological writings can be construed as good illustrations of the principles of *local contextualist epistemology* (though he never explicitly articulated this position) rather than flights of global theory, such as structural functionalism or systems theory. Srinivas' work covered a vast terrain: village studies, caste and social structure, social change, religion and cultural studies, gender studies.

Srinivas' most fundamental methodological contribution consisted of his breaking out of the confines of the textual authority of Sanskrit studies that defined the scope of his discipline. During the colonial period, the Indian society and its social structure were viewed as static and unchanging. The approach to the study of Indian society was through the mediation of a combined approach of Indology and sociology and heavily relied on the classical texts. Srinivas' first book entitled *Religion and Society among the Coorgs of South India* (1952)[57] based on an ethnographical study of the then little known Coorg community marked a complete departure from, what he himself called, the "book view" to "field view" of the study of Indian society.

From then onward, his social laboratory became the village, factory, and home: the places where people lived, worked, and in general played out a multiplicity of social and cultural roles. This prime importance given to close and insightful observation of men and their changing roles in the society could be the foundation for innovative theory construction. Srinivas had the rare gift of converting insightful observations into major innovative sociological *concepts* and *theories* that have changed the theoretical landscape of Indian sociology.

The best example of Srinivas' fieldwork is his socio-anthropological studies of the village of Rampura near Mysore carried out in 1948 and published in 1976 in the form of a book entitled *The Remembered Village*.[58] This won him international recognition and firmly established his unique scholarly position.

However, he is more well known for his ideas on social change and modernization anchored in another study, which could be regarded as the finest example of "local realism" and "contextualist epistemology."

Based on the painstaking ethnographical study of the Coorg community in 1952, Srinivas introduced certain seminal ideas in the theory of social change in India. In opposition to the colonial notion of a static and unchanging Indian society, Srinivas sought to capture the fluid and dynamic nature of Indian social structure and caste as a social institution in terms of some of the most innovative concepts that have now become an integral part of Indian sociological theory, such as "sanskritization," "dominant caste," and "vertical intercaste and horizontal intracaste solidarities." The concept of "sanskritization" seeks to describe the process by which castes placed lower in the caste hierarchy seek upward mobility by emulating the rituals

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[57] Srinivas (1952).

[58] Srinivas (1976).

and practices of the upper or "dominant castes." This analysis of change in the social structure had several methodological lessons for social scientists: (1) it validated the importance of fieldwork as an essential methodology for Indian sociologists and social anthropologists, and (2) it replaced the widely held idea of a rigid pan-Indian caste system by the regional dimensions of caste system conveyed in terms of another innovative idea introduced by Srinivas, viz., the "little tradition" of Hinduism. The more recent theories of modernizations had to take note of the fact established by Srinivas that with certain adaptations, the caste system in some form is here to stay.

3.10 Conclusion

The problem of generalization and the assumptions about unobservable entities and mechanisms plagued the logical positivistic account of scientific knowledge. A viable alternative to this account appears to be a *local contextualist epistemology* grounded in doing science, getting involved in actual issues faced by a given science, and taking a natural ontological attitude. Two good illustrations of this approach were given from the works of Amartya Sen and M.N. Srinivas.

Appendices

Appendix 3.1: The Transcription of a Babylonian Ephemeris

(a) The Transcription

Year	Successive months of the year	Monthly progress of the sun across the zodiac	Anticipated position in the zodiac of the conjunction	Sign of the zodiac
2, 59 {Seleucid era, i.e., 2 X 60 + 59 = 179 after 312 B.C. or 312–179 = 133–2 B.C.}	I	28, 37, 57, 58	20, 46, 16, 14	Taurus
	II	28, 19, 57, 58	19, 6, 14, 12	Gemini
	III	28, 19, 21, 22	17, 25, 35, 34	Cancer
	IV	28, 37, 21, 22	16, 2, 56, 56	Leo
	V	28, 55, 21, 22	14, 58, 18, 18	Virgo
	VI	29, 13, 21, 22	14, 11, 39, 40	Libra
	VII	29, 31, 21, 22	13, 43, 1, 2	Scorpio
	VIII	29, 49, 21, 22	13, 32, 22, 24	Sagittarius
	IX	29, 56, 36, 38	13, 28, 59, 2	Capricorn
	X	29, 38, 36, 38	13, 7, 35, 40	Aquarius
	XI	29, 20, 36, 38	12, 28, 12, 18	Pisces
	XII	29, 2, 36, 38	11, 30, 48, 56	Aries

(b) The rule for computing the position, taking the example of month II to month III and the transition from Gemini to Cancer

From the given position in Gemini	19, 6, 14, 12
Add the monthly progress of the sun	+ 28, 19, 21, 22
	47°, 25, 35, 34
Subtracting 30°	−30°
The position of conjunction at cancer	17, 25, 35, 34

(c) The table indicates a cycle based on arithmetical progression, i.e., increase and decrease with constant fixed difference between two limits (between 28 and 30)

Months	Decrease	Increase
I–II	18′	
III–VIII		18′
IX–XII	18′	

Appendix 3.2: Aristotle's Science of Motion Based on Inductive-Deductive Method

In his treatises, *Physics* and *De Caelo (On the Heavens)* upheld *four doctrines*. They are:

- Doctrine of essentialism: discovering the *essential* of an individual/object ("*phusis*" = nature) and demonstrating why, in order to fulfill its *function*, it has to have the essential property.
- Doctrine of four elements: that all naturally occurring substances are made out of four fundamental elements – earth, water, air, and fire.
- Doctrine of natural place: each of the fundamental elements has a *natural* level of existence, i.e., when displaced, they seek/have a tendency or desire to revert back to their natural level of existence.
- Doctrine that presented a *worldview* that the universe is an organism, anthropomorphic or human centric, and teleological.

Aristotle's anthropomorphic or human centric and teleological imply that any attempt to explain the behavior of an inanimate/material body:

- Must be made in the analogy with a living organism
- Must be given in terms of its own nature (essence), tendency, desire, motive, goal (teleos), or final cause

For example:

– *The nature (essence) of a heavy element*, such a lump of earth, is to go down.
– *The nature (essence) of a light element*, such as air/fire, is to go up.

These are *natural motion* of these objects.

From this doctrine of essentialism, attributing *essential property*, *Aristotle's* four first principles (*archai*) follow:

Aristotle's four first principles (*archai*)

- All motions are either *natural* or *violent.*
- All *natural motion* is a motion toward a natural place.
- All *violent motion* is caused by the continuing action of an agent.
- Vacuum is impossible (because in that case all bodies will move with equal velocity, which is impossible).

Based on the three doctrines and four first principles, Aristotle and his followers go on to formulate certain "laws of motion":

Aristotelian laws of motion
Further assumption of Aristotelian laws of motion:
For Aristotle, in all motion (natural or violent), two major factors play a role:

– The motive force, denoted by F
– The resistance of the medium, denoted by R

The statement of Aristotle's laws of motion:

From observation, Aristotle concluded that for motion to occur, it is necessary that:

- The motive force must be greater than resistance, i.e.,

$$F > R \tag{3.1}$$

In other words, when motive force overpowers/overcomes resistance, motion takes place.

- The greater the resistance, the smaller the speed, or speed is inversely proportional to the resistance of the medium through which the body moves, i.e.,

$$V \propto 1/R \tag{3.2}$$

[Note: this should not be read quantitatively, i.e., as double the speed 1/2 the resistance.]

- Consequently, the greater the force to overcome the resistance, the greater the speed:

$$V \propto F \tag{3.3}$$

- Combining Eqs. (3.2) and (3.3), we get a single equation, viz.,

$$V \propto F/R \tag{3.4}$$

That is (*in modern language*), speed is proportional to the motive force and inversely proportional to the resistance of the medium. Or speed is proportional to the force divided by the resistance.

Consequence of Aristotle's Law

Consider dropping two objects in the same medium, say air, where the weight of one is exactly twice the weight of the other.

- For Aristotle, the speed of the heavier object, which has twice the motive force (since it has twice the weight of the other), should be exactly twice that of the lighter one.

Based on such reasons, Aristotle concludes that the speed of a falling body is proportional to its weight.

- For a constant distance of fall, the speed would be inversely proportional to the time such that the heavier the object, the less time will it take to descend, i.e.,

$$V \propto 1/T$$

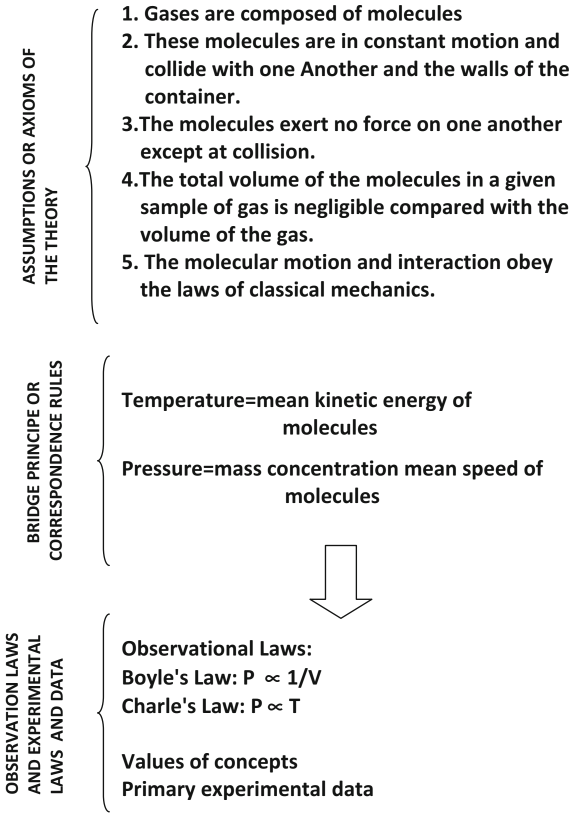
That is, the speed is inversely proportional to the time of descent:

- $V1/V2 = T2/T1$

That is, the time of descent of the heavier object would be just half the time of descent of the lighter one.

- Hence, for Aristotle, the time of free fall in a given medium is inversely proportional to the weight of the object.

Appendix 3.3: Kinetic Theory of Gases



Appendix 3.4: A Note on Reconceptualizing Induction, Induction and Natural Kinds

Problem with Induction: "Hume's Problem"

Hume (1711–1776) in his *Treatise* (1739/1888) raised a serious problem relating to universal general statement or scientific hypothesis arrived at as an inductive conclusion from evidence statements. The universal general statements in science are the hypotheses and laws that make up theories; the particular statements are observations or reports on experiments. Specifically, Hume targeted induction as not being a logically sound form of inference. The problem of induction is the problem of justifying the formation of universal statements from particular ones – with incomplete data at hand.

Induction by virtue of going beyond the evidence – from particular to the general – is *ampliative* (meaning "to enlarge" or "to extend": adding to that which is already known). Hume maintained that there are no objective necessary connections among the attributes of phenomena given in ordinary experience. It follows from this that the only grounds that we have for inferring from a sample to a population or from the past to the future are given by present experience or memory. Hence, induction lacks *soundness* [59] and is *nondemonstrative* (i.e., an inductive argument is not necessarily valid, and it is not the case that whenever the initial statements, i.e., premises or axioms, of an inductive argument are true, the conclusion is also true). Unlike deductive argument, inductive inferences can never achieve apodictic certainty.

Reconceptualization of Induction: The Notion of "Natural Kinds"

Hume's problem does not lead, as some have suggested, to skepticism about all events beyond present experience; nor does it imply that all such judgments are somehow unreasonable or unjustified.[60] Particular observations are treated by many logicians as "good reasons for belief" in a universal generalization.[61] One of the implications of this is that our notion of rational justification ought to be adapted to this fact.

New Way of Looking as Inductive Generalization: An Essentialist Response to Hume

Essential properties typically involve reference to the microstructure of things. Having atomic number 79 is said to be the essential property of gold,[62] being H_2O the essential property of water.[63] Genetic makeup similarly enables us to identify essential properties for animals and plants, and the mean molecular kinetic energy is taken to be the defining property of temperature. These essential properties characterize *natural kinds* and are furnished by the natural sciences:

> In general, science attempts, by investigating basic structural traits, to find the nature, and thus the essence (in the philosophical sense), of the kind. (S. Kripke [1972], p. 330)

[59] Proofs given by Broad (1918, 1920) and Salmon (1967).

[60] Strawson (1952/1962).

[61] Black (1967).

[62] Kripke (1972, p. 327, 1971).

[63] Putnam Hilary (1975).

Natural Kind and Generalization

Natural kinds, therefore, are characterized by the possession of an essence, that is, a set of intrinsic, causally explanatory properties that are necessary and jointly sufficient to belong to the kind.

The causal notion of natural kind has been developed by Boyd[64] and Griffiths[65]: a class C of entities is a natural kind if and only if there is a large set of scientifically relevant properties such that C is the maximal class whose members tend to share these properties because of some causal mechanism.

Moreover, the causal notion of natural kinds in these cases is not vacuous. It implies that *nominal kinds*, for instance, the class of physical objects that weigh more than 30 kg, are not natural kinds, for their members don't share (scientifically relevant) properties. For example, many *subsets* of natural kinds, e.g., white dogs, are not natural kinds, for such properties are accidental and true of the subset. Hence, the natural kind assumption says that it possesses three characteristics:

- There is a set of properties that a specific natural kind tends to possess.
- These properties of natural kind help in making generalizations about its members.
- A given natural kind possesses these properties because of some causal mechanism.
- Natural kind terms feature in laws, i.e., in generalizations that are temporally and spatially unrestricted and that support counterfactuals.[66]
- Natural kind expressions feature or could feature in the laws in natural sciences or scientific laws and theories.

Natural Kind and Induction

The notion of natural kind is essentially tied up with induction as claimed by Mill, Quine, Boyd, and Hacking.[67] For the notion of natural kind supports nonaccidental, scientifically relevant inductive inferences. Kornblith in his *Inductive Inference and Its Natural Ground*[68] says:

> Natural kinds make inductive knowledge of the world possible, because the clustering of properties characteristic of natural kinds makes inferences from the presence of some of these properties to the presence of others reliable.

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64 Boyd (1990), And (1991).

65 Griffiths (1997).

66 Collier (1996).

67 Mill ([1843] 1905), Quine (1969), Boyd (1990), And (1991), Hacking (1991).

68 Kornblith (1993).

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