Inductive Logic:

An Examination and Review of Its Applications and Limits

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Abstract

The concept of inductive reasoning along with that it entails, is a vast and varied subject. Induction is the process of analyzing the probability of risky arguments. Inference is the process of hypothesizing a conclusion. Testimony is a type of argument that uses the oftentimes-unreliable word of others to draw a conclusion.

The tools employed by inductive logic include the deductive disciplines of statistics, probability, and causality. In statistics, sample and population size play an important role in the strength of the argument. The rules of probability allow us to examine how probable an inductive conclusion is. Causality shows the necessary and sufficient conditions that allow us to draw conclusions inductively.

Inductive logic is applied in many disciplines, including the sciences, law, and philosophy, as well as in everyday life. Science employs inductive reasoning to hypothesize on all manner of occurrences. Lawyers employ inductive reasoning when arguing a case before a judge, who must then use induction as well to adjudicate the matter. Philosophers sometimes employ induction to help them in areas where their favorite tool deduction fails. Day in and day out, people all over the world use inductive reasoning when making all manner of decisions, be they important or trivial.

But, inductive reasoning does have its limits. The trade off for its ability to bring new knowledge to the table is the degree of risk the arguer assumes.

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A logical argument is a group of statements, or propositions, one of which (the conclusion) is supposed to be supported by the others (the premises). Logic has two main branches: (i) deductive logic, which is the study of certain arguments, and (ii) inductive logic, which is the study of probable arguments. The focus here will be on inductive logic.

Hacking (2001) states that inductive logic analyses risky arguments, as opposed to deductive logic, which studies risk-free, valid arguments. Most arguments advanced in everyday life are arguments from induction. No matter how good a risky argument is its conclusion may still be false (p. 11).

1. Types of inductive arguments

Inductive arguments take many forms, and it is often difficult to discern one from the other. Induction is characterized by its reliance on the deductive tools of statistics, proportions, probability, and causality. Inference is rooted in hypotheses, which are purported to be inferred from an extraordinary premise and a categorical premise. Testimony, the weakest type of inductive argument, uses another person's words as premises to support a conclusion that goes far beyond the original premises.

1.1. Induction

Unlike deductive arguments, which are either valid or invalid, inductive arguments are either strong or weak. Just like a deductive argument, which is valid if and only if it is impossible for the conclusion to be false given the premises are true, an inductive argument is strong if and only if it is improbable for the conclusion to be false given the

premises are true. According to Skryms (1986), the strength of an inductive argument is derived from the strength of the premises, i.e. the weight of the evidence for the inductive conclusion (p. 7).

In a deductive argument, the premises are presented, and the conclusion is seen to follow implicitly from them. On the other hand, Skryms (1986) says, an inductive argument presents premises, and a probable conclusion is drawn, going beyond the facts displayed in the original premises (p. 8).

Hacking (2001) reports that "Inductive logic analyzes risky arguments using probability ideas (p. 18)." This will be the main focus of this survey.

1.2. Inference

Another argument form of inductive logic involves something called inference. Inferential arguments employ a mainstay of science, the hypothesis.

An inference begins with somebody noticing something, usually out of the ordinary. The arguer then states a categorical proposition, which is assumed to be true. At that point the arguer does not turn to statistics, proportions, or probability, but to one or more hypotheses. The argument infers that the hypothesis (or hypotheses) explains the extraordinary.

Hacking (2001) states that as long as the hypothesis is within the realm of possibility, it is referred to as a plausible explanation. If more than one hypothesis is proposed, the most plausible is called the best explanation. Thus, an inferential argument is either an inference to a plausible explanation or an inference to the best explanation (p. 16).

According to Hacking (2001), the curious philosopher C. S. Peirce (pronounced 'purse'), claimed that inferential arguments were a logic all to themselves, calling it 'ab-

duction' (pp. 16-17). However, most philosophers and logicians still classify inference with induction.

Arguments from inference are still risky arguments, for they rarely have solid premises upon which to stand. Although inferential arguments are found throughout the sciences, the focus here will be on induction.

1.3. Testimony

Another person's word is a very powerful thing in life. Hacking (2001) claims that "Most of what you believe, you believe because someone told you so (p. 17)." But, just how trustworthy are others?

Inductive arguments can also take the form of testimonials, where a person's word about something is used as the sole premise (or premises) for a conclusion. Like induction and inference, testimony, too, is a risky business. The arguer may be misinformed, ignorant, or biased.

Although probability may be used to examine testimony, there is more to testimony than simple probability. Again, the focus here will be on induction.

2. Tools of inductive logic

The tools employed by inductive logic are actually deductive elements of mathematics. They are used to make inductive arguments as strong as possible. Statistics, proportions, probability, and causality all play a part in inductive logic. These tools are not restricted to inductive logic, and may also be employed in deductive logic.

2.1. Statistics

Statistics play a large role in inductive logic. Hacking (2001) explains that many inductive arguments draw a conclusion about a large population from a relatively small

sample. One may also induce in reverse, i.e. from something known or supposed about an entire population, to conclude about a sample from the population. It is also possible to induce something about one sample, from a previous sample of the same population (pp. 12-13).

Here are some examples, according to Hacking (2001), explaining the role of statistics in inductive logic:

EXAMPLE 1: A man runs a fruit stand and sells his old fruit at a cut-rate. A lady wants to buy a box of apples, at the lowest possible price, but she would like them to be good and ripe. The man cuts open an apple from the box, showing her that it is not rotten. The man's argument is as follows:

Premise: This apple is good.

Conclusion: Almost all the apples in the box are good.

The man's argument is not a valid argument. It is possible for the cut apple to be ripe, while much of the remainder of the box is rotten. It is, however, an inductive argument, even if the premise does not supply very good evidence.

EXAMPLE 2: Now the same lady takes another apple from the box and cuts it open. It too is ripe. If she buys the box, her argument would be as follows:

Premise: This apple I chose is good.

Conclusion: Almost all the apples in the box are good.

Even though this argument produces the same conclusion as in the first example, it is not as risky as the first. The sample size of the population has been increased.

EXAMPLE 3: Suppose the lady now chooses five random apples from the box. Four of the five are ripe, while one is rotten. If she bought the box now, her argument would be as follows:

Premise: Of the five apples I chose, one (or 20% of the sample) was bad.

Conclusion: Most (about 80%) of the apples in the box are good.

Again the sample size has increased, and, statistically speaking, this argument is less risky than either of the preceding examples. However, it is still not a valid argument; most of the remaining apples might be rotten (pp. 11-12).

2.2. Proportions

Hacking (2001) explains that proportions may also be employed in inductive arguments, as indicated above in example three with the information in parentheses. Proportions allow an inductive argument to be more exact (p. 13).

2.3. Probability

Probability, claims Hacking (2001), is the fundamental tool of inductive logic. It is used to study risk, and numerical probability allows one to evaluate which arguments are riskier than others. It is important to understand that not all arguments that use probability are inductive. Likewise, all arguments containing probabilities are not necessarily risky, because probability itself can be calculated mathematically, using deductive arguments (p. 14).

Statisticians usually talk about the probability of events, in what can be called event language, while logicians usually refer to the probability of propositions, in what can be called proposition language. According to Hacking (2001), event language can be translated into proposition language for use in inductive logic (p. 38).

It is generally understood that probabilities must be greater than zero and less than one. They can be expressed as either fractions or percents. An event or proposition that is certain to happen has a probability of 1, while any event or proposition that will certainly not happen has a probability of 0.

When examining probabilities, two events that cannot both be true at the same time are referred to as mutually exclusive. Hacking (2001) states that this may be transferred into inductive reasoning by saying that two propositions that cannot both be true at the same time are mutually exclusive. They can also be termed disjoint (p. 40). Once it is claimed that two propositions are mutually exclusive, the probabilities of those propositions can be added to determine the probability of the disjunction of the two propositions. One must be sure that the propositions do not contain any elements that overlap.

Hacking (2001) also states that another important quality of events that may be translated to propositions is independence. Two propositions are said to be independent when the truth of one event does not influence the truth of another event (pp. 41-42). Once it is claimed that propositions are independent, the probabilities of those propositions may be multiplied to determine the probability of the conjunction of the two propositions. Again, one must be sure that the propositions do not contain any elements that overlap.

The concept of compounding, says Hacking (2001), also plays a part in probability. An event is said to be compound if it is composed of two or more distinct events. In some arguments, one may find a proposition that itself is the function of two or more other propositions (pp. 43-44). The probability of such a compound proposition must be

calculated as a disjunction or conjunction, depending on the exclusivity and independence of the component events.

Hacking (2001) distinguishes between categorical and conditional events in probability. A categorical probability (or proposition) makes a definite, unconditional claim (that can be either true or false). A conditional probability (or proposition) makes a claim about something, which is contingent upon another possibility (which can either be true or false as well). An assertion such as 'the probability of dealing an ace as the second card, given that a king was dealt first, is 4/51 or about 7.8%' is conditional; a proposition is either more or less probable, given that another proposition is either more or less probable (pp. 47-48).

2.4. Causality

Causality, according to Skyrms (1986), strives to produce the cause in order to produce the effect, or to prevent the cause in order to prevent the effect. One must know the causes to control the effects (p. 84).

One must take care when determining causes not to confuse correlation with causality. Cederblom and Paulsen (1991) state that if one proposition is the cause of another, then this states that the second proposition would not be true without the first proposition being true. This is different from correlation, or when two propositions are merely true at the same instance (p. 236).

In determining causality, one should think in terms of sufficient conditions and necessary conditions. So that: (i) Proposition A is a sufficient condition of proposition B, if and only if whenever A is present, B is present; and (ii) Proposition A is a necessary condition of proposition B, if and only if whenever B is present, A is present. It also fol-

lows that if A is a sufficient condition of B, then B is a necessary condition of A; and that if A is a necessary condition of B, then B is a sufficient condition of A.

Skryms (1986) reports that philosopher and logician J. S. Mill perfected five methods for the arguer to determine causality. They include the direct and inverse methods of agreement, the method of difference, the joint method, the method of concomitant variation, and the method of residues (p. 88).

3. Applications of inductive logic

3.1. Science

Because inductive logic provides for the discovery of new concepts on the basis of established facts, it is the perfect tool of science. Science uses hypothetical reasoning, which, from above, is called inference, as well as induction.

The scientific method itself is a function of induction and inference. Recalling from the definition of inference, an extraordinary premise and a categorical premise are used to infer a conclusion, which, itself, may be completely new information. In the sciences, these types of inferences are very common. Hacking (2001) explains that the Big Bang theory of the universe is one such theory (p. 16). Popper (1979) reminds us to be wary, though, by saying claims require justification. “All theories are hypotheses; all may be overthrown. (p. 29)”

While some scientific theories are inferences, most are inductions. The rules of probability, statistics, and proportions can be applied to hypotheses to determine how probable are those hypotheses. Theories can change, because over time the statistics of samples and populations may change as well. Causality, too, plays a large part in scien-

tific theories, telling the scientist about necessary and sufficient conditions for the hypothesis.

3.2. Law

The legal system is probably the most perfect outlet created for the use of inductive reasoning. Arguments presented in the legal systems of western nations are very often analogical arguments. According to Hurley (2000), many legal systems require similar cases to be decided on precedent (p. 488). An analogical argument attempts to show that a particular conclusion is analogous to the conclusion of another argument.

This system came about through a process. Hurley (2000) states that centuries ago, cases were decided by judges who made particular rulings. These rulings became known as common law. Later, legislative bodies came to produce laws, called statutes, which may be based on common law as precedent. Today, a judge is required to base a ruling on the precedent of common law, or statutory law (p. 489).

Analogical arguments utilize induction, probability, and inference to prove their conclusions. The analogy itself must be inferred, and then the probability that the analogy is strong may be examined.

3.3. Philosophy

Although philosophy usually employs deductive reasoning, inductive reasoning is sometimes utilized. The majority of philosophers, especially moral philosophers, employ induction and inference on occasion.

3.4. Everyday life

In practical ethics, people in general employ analogy, inference, and induction. In deciding on a moral issue, one often infers a connection with an analogous issue and then

induces a conclusion, based on small samples and populations. The decision itself becomes relative, given there is a sample of a specific population. Still, deductive reasoning gives a person a risk-free means of assessing an issue

People, in general, seem more likely to employ inductive reasoning on a regular basis, as opposed to deductive reasoning. This would not be such a bad thing, except that, in his induction, the arguer often makes untenable analogies and inferences based on small samples of a small population, as well as utilizing unreliable testimony from unqualified individuals.

4. Limits of inductive logic

Both deductive logic and inductive logic make trade offs. Deductive logic discards the possibility of new discovery and innovation for the certainty of being absolutely correct. Inductive logic gives up that very certainty so that new ideas and concepts are indeed possible.

But, how much of a risk is one willing to take when employing inductive logic? As one can see from the applications listed above, inductive logic is found practically everywhere. In fact, the preceding statement is an induction:

Premise 1: Because inductive logic is used in science, law, and philosophy;

Premise 2: And, because inductive logic is employed in everyday life;

Conclusion: Then it is probable that inductive logic is used in every discipline.

The risk assumed in this argument is that inductive logic may not be found in every discipline. A small sample of disciplines is reviewed, and then a conclusion is drawn about the entire population of disciplines.

One need not go any further than the preceding argument to discern the limits of inductive logic. If the probability of any of the premises of an argument is less than one (certain), then there is room for that percent of unsurety, no matter how small it is. If all the premises of an inductively strong argument have a probability of 1, then the argument is no longer inductive but deductive. At that point no new conclusions could be drawn, and the tautologous (always valid in every situation) universe would take control.

The limit of inductive logic is, therefore, the probability of one. Inductive premises should describe probability and discard certainty. This is the only way to discovery and innovation.

Conclusion

After a brief introduction to inductive reasoning, one can see the intricacies involved in producing an inductive argument. Far more complex than deductive logic, what has been reviewed here is merely the tip of the iceberg when it comes to inductive reasoning. And this seems sensible, in that deductive certainty is a rigorous study of validity, while inductive probability is anything but rigorous. All manner of factors, inconceivable in deductive logic, make their presence felt in inductive reasoning. Induction is the best tool available to mankind when discovery and innovation are at stake.

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