

Lecture 09: Statistical Arguments

Taylor Arnold

Statistical Arguments

There are two basic approaches to making logical arguments, both of which have a place in making arguments from data. These are:

- ▶ deductive reasoning
- ▶ inductive reasoning

I find that while most students have heard of these distinctions, rarely can they concisely describe them. As each requires a fairly distinct rhetorical approach, let's cover these briefly.

deductive reasoning

In deductive reasoning we start with general assumptions and show that certain conclusions logically follow from them. A classic example is:

*Socrates is a man. All men are mortal. Therefore,
Socrates is mortal.*

If the assumptions of this statement (first two sentences) are true, the conclusions **must** be true.

deductive reasoning - statistics

Deductive reasoning occurs in statistics when some of our facts (assumptions) are derived from an analysis of a dataset. Generally this occurs when we are drawing data from a **population**.

For example, say we are looking at election results from every county in the United States. The following is a deductive argument:

A presidential candidate that has more than 270 electoral votes wins the election (assumption). Candidate A had 300 elector votes in 2020 (assumption derived from data). Therefore, candidate A won the election.

Notice that often not **all** facts are derived from data, but importantly some are.

inductive reasoning

Inductive reasoning, in contrast, builds a conclusion by inferring based on patterns seen in particular examples. For instance:

I have taught a total of 700 students over the past 5 years. I enjoyed teaching all 700 of them. Therefore, I enjoy teaching all students.

While the data provides strong evidence for the conclusion, it does not guarantee its validity even if the assumption and logic is infallible.

Inductive reasoning usually occurs in statistics when sampling from a larger population or observing a random process. For example:

Only 1 of the 1000 patients injected with the vaccine had serious side-effects. Therefore, the vaccine is safe for distribution.

While inductive reasoning is more traditionally associated with statistics, the deductive case is quite common in both industry and academia.

hybrid approach in statistics

Often, in an analysis of data I have observed a hybrid approach. Namely, deductive reasoning is used to draw concrete conclusions from data. These conclusions are then used as part of a larger inductive reasoning.

For example, assume that you are a statistician working for a large company and analyzing financial data. Using the data, you may confirm that the company has increased year-over-year profits by 232% (by deductive reasoning). From this evidence, the company decided to proceed with an IPO (by inductive).