Discussion: Bayesian vs. Frequentist Methodology in Economics

What are Frequentist and Bayesian Inference?

> *(See Frequentist Inference, Bayesian Inference and this video for a more visual explanation. Likely also more accurate. The dicussion skips over many points in favour for simplicity. If you like to know more, just continue studying, ask your favourite professor or tutor, and of course, join our discussion.)*

To answer what frequentist and bayesian inference are, we first need to answer what inference is. Inference, in its most simplistic description, is the act of gaining knowledge about some parameter of interest using some observations. It is to an econometrician, what butter is to bread. If you are a first year, most of your following years will be spend learning about how to do inference. Most of this training will, however, only cover frequentist inference. Frequentist here means, that it adheres to the frequentist interpretation of probability. This interpretation takes the form of frequencies, hence the name. A probability of 50% heads would mean that if we were to flip the coin infinitely many times, then half of the flips would end up being heads. The bayesian interpretation of probability does not follow frequencies but rather beliefs. A Bayesian might put the probability of 50% on heads not because in the limiting case this will be the frequency of heads appearing, but rather because she thinks that both sides of the coin are equally likely to show up. Essentially both talk about probabilities, but Frequentists look at the limiting case, while Bayesians talk about their beliefs.

The frequentist approach does also mean, that ones the coin was flipped, but the flipping person is still covering the coin, you cannot put any probability on heads being up. In a frequentist world, at this point in time, the coin is either heads up, or heads down. Thus the only allowed probabilities are 1 or 0. A Bayesian, on the other hand, can still assign any probability to either event. Frequentists can thus not assign a probability to a hypothesis, while Bayesians can. This difference also highlights the varying views on what parameters are (these are the things one would like to estimate to, for example, say what affect education has on wage). In the Frequentist world, there exists one true parameter that is fixed and does not vary. On the other hand, Bayesians usually consider the paramter to be random and infer a whole distribution, the posterior distribution. Bayesians can thus assign a probability to the hypothesis that education has a positive impact on wage (it is usually very likely, so don't forget to study!). Frequentist cannot assign probabilites. To test hypothesis, they usually use p-values. A value specifying how likely it is to make an observation at least as extreme as the one you made, given the null-hypothesis is true. They can then either reject the null, in favor of the alternative, or fail to reject the null, and thus stick to their default action.

The two parties also differ in the ways they estimate the parameter. Bayesians have a prior, a distribution representing the belief about the parameter before data is observed, and combine this prior with a likelihood to arrive at a posterior distribution. This posterior distribution can then be used to form a point estimate, usually the mean, and a credible interval. A point estimate is just one point, while a credible interval is often an interval of the form $(a, b),\ a \leq b$. If the latter is a 95% credible interval, then the parameter is with 95% probability within this interval, given the data and your prior beliefs. Frequentists, on the other hand, do not use priors beliefs, but rather estimate the paramter, in what they call, an "objective" manner. They then communicate their estimates in point-estimates and confidence intervals. Although confidence intervals have often the same form as credible intervals, the bounds are actually considered random variables themselves. A confidence interval *does not* give the probability that the parameter lies within the interval, but rather says, that when the experiment was to be repeated over and over again and this method would be used to determine the confidence interval, then the true parameter would lie x% of the time within the interval.

Bayesian Inference: The way to go?

> *(Please see the links below to get inspired for the discussion. We are looking forwared to hearing your opinion. The following is meant to be intentionally provoking)*

Having talked about the two camps, it is time to go to the battle field. Over many decades statisticians have fought about what the right way of doing statistics is. Should it be Frequentist inference, Bayesian inference, or perhaps something completely different? This is, however, an old discussion and the conclusion is mostly that both Frequentist and Bayesian approaches have their advantages and disadvantages and that it completely depends on the area of application. This, then started a new discussion in many fields of science. Which of the two approaches is the right approach in a specific field. Given we are econometricians, a subset of economists, it is thus only natural to ask: **Which of the two approaches is the right approach in economics?** Well, the answer should be easy: Given pretty much all your education will support the Frequentist paradigm, it must be Frequentist inference; Why should you otherwise not cover anything else? But it is not as easy as it might sound, and the Bayesian paradigm might actually be the better one and the one you should learn first.

The Frequentist approach has indeed many disadvantages, the biggest of which is the nonesense assumption that you can repeat an experiment over and over again (a neccessity for the interpretation of confidence intervals). This labouratory assumption just does not apply to any economic application outside behavioural economics expereiments. Policies are usually just ones introduced, and most economic events happen in the form they happen only ones. We are not able to repeat the financial crises in the same way it happened, even if banks will make the same mistakes again. It is just not possible, because the people, or agents like economists often call them, learned from the past. They have seen it before. They will thus very likely not behave like they did back then. **So why carry on with this assumption? Why carry on using the Frequentist approach and not the Bayesian approach, which does not need this assumption?**

The Bayesian approach could be the answer. With its definitaion of probabilites as beliefs it fits better to how people actually use the information gained from inference in economic contexts. It furthermore allows to assign probabilites to hypothesis, a much more intuitive concepts than that of a confidence intervals. This also shows that the Bayesian paradigm might be much better suited for a first education in statistics than the Frequentist paradigm. Moreover, the possibility to assign probabilities to hypothesis allows to answer questions such as: How likely is it that people will consume more if the ECB decreases interest rates? This kind of question might be much more suited for policy making than only the binary variant: Do people consume more if the ECB decreases interest rates? The latter does just not allow for the same treatment of risk in policy making.

Do not let me fool you though! The Bayesian paradigm has many disadvantages too. One that is mostly pointed out by Frequentists is that in order to make any inference, Bayesians need to have a prior. This is often considered to be not objective, and indeed some priors can produce completely nonesense estimates. Moreover, the fact that there does not exist "one true parameter" in the Bayesian paradigm makes it impossible to answer questions such as: What is the ability of my method to deliver the right answer? **How can there exist a world without a right answer?** Furthermore, interpreting the probabilities as beliefs raises questions such as: **What is a belief? How is a belief of 90% interpreted?** The Frequentist paradigm is just better in this case. A probability of 90% for some event means that if I was to repeat my experiment over and over again 90% of my observations would correspond to this event. Frequentism also allows to sort out hypothesis, something that is difficult in the Bayesian paradigm. If we are able to anwer whether a hypothesis is unlikely to be true, then we are slowly able to narrow our hypothesis space to only hypothesis which were not rejected by the data. All Bayesians can do is sort according to probabilites, but without using another rule, like always discarding the lower probability hypothesis, they will not be able to narrow down the space; **Something that should be the final goal of science?**

Join the Discussion

Many more arguments exist for both, the Frequentist and the Bayesian paradigm. The links below represent some of them (It is mentionable that a lot of them represent the Bayesian paradimg, which was done intentionally, because most of the readers will already be very familiar with the Frequentist arguments, or are better bale to form Frequentist arguments on their own) Beware: some of them are very thought provoking and might make you angry, or stop you from falling asleep. They might also make you start questioning what your learn. But is that not what studying should be all about? Questioning what you learn; questioning your views; forming new ones, repeatedly, until eventually you arrive at something that was not known to you or even others before; until you are able to do something you were not able to do before; understand something you did not understand before.

We are very much looking forward to the discussion and hope this text could inspire you to join. If you are a first-year or just not very confident, fear not. Arguments that are understandable to all levels of education are preferred, and many of the points made here are more of a philosophical than of a mathematical nature. We are also very happy if you just join to listen in.

Links

https://davegiles.blogspot.com/2014/06/frequentist-vs-bayesian-analysis.html
https://www.mn.uio.no/math/english/research/projects/focustat/the-focustat-blog%21/toreblogg.html
https://pubs.aeaweb.org/doi/pdf/10.1257%2Fjep.2.1.121
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https://www.youtube.com/watch?v=GEFxFVESQXc
https://en.wikipedia.org/wiki/Frequentist_inference
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