

Responsible Citizenship in a Technological Democracy

Note 9: Precision vs. Accuracy

A pernicious problem in many public policy debates is to confuse “precision” and “accuracy”. Accuracy refers to correctness. Precision refers to exactness, especially with respect to measurements. So, 3.1415926 is more precise than 3.14 as the value of π (the ratio of the circumference to the diameter of a circle), but neither is accurate if the original question was “how many days are there in a fortnight?”

Concept: Precision does not imply accuracy. Precision may sound authoritative, but be wary!

The courts recently disallowed the use of the analysis of trace elements in bullet lead as evidence, even though these trace elements can be measured so precisely that we can have high confidence that two bullets came from the same batch of lead. This had been used for years as evidence against a person when bullets from the same batch of lead were used in a crime and were also found in possession of the suspect.

The problem is that the manufacturing and packaging processes so thoroughly mix bullets from different batches of lead that it’s probable that a bullet from the same batch could be in almost anyone’s possession – well, anyone who has bullets, of course. It’s also possible that the bullet used in the crime was the only one from that batch in a particular box, so the lack of a match doesn’t prove innocence either.

A somewhat similar situation pertains to the current discussion of uranium enrichment in Iran and the possibility of them getting an atomic bomb from it. As with the bullet lead, what you need is an accurate answer to the right question, not just a precise answer.

First some background. You don’t need to know the details, but there are two kinds of uranium called U_{235} and U_{238} respectively. “Enrichment” refers to increasing the fraction of a particular uranium sample that is U_{235} . That’s the stuff that can be made to heat up a power plant or to go boom. In natural uranium ore, there is 1-2% U_{235} . For power plants that must be increased to 5-8%, for bombs it has to be increased to 90-95%.

Back to the policy issue: If you ask about the Iranian nuclear program, the answer you are likely to get is that they have 3,000 centrifuges (devices to enrich uranium) and could make enough highly enriched uranium to build a bomb by some particular date¹. That isn’t what we need to know! Are they, in fact, only enriching to 5-8% or are they going all the way.

The thing for you to remember is that *precision does not imply accuracy*. Get suspicious when folks start throwing around impressive sounding numbers, like 3,000. Maybe they are relevant,

¹ Lots of dates have been suggested, from “almost now” to “ten years from now.”

but maybe not. Try to think about what the *real* question is, and whether the numbers are answering it.

- The question wasn't whether you can determine whether two bullets came from the same batch of lead, but rather whether coming from the same batch (or not) proves anything.
- The question isn't whether Iran has centrifuges, but whether they are being used to create the bomb-grade stuff.

It's also good to remember to calibrate numbers. Is 3,000 a big number? Clearly, it depends. If I owned that many antique cars, then yea, it's BIG. If it's the number of transistors on a chip, it's *tiny* (there are a hundred million on contemporary chips). Numbers can also be time dependant – 3,000 transistors on a chip was a huge number in 1960, but a *tiny* one now – so be sure to factor that into your thinking.

By the way, the centrifuges that Iran has are an older model and are much less efficient than modern ones. A “production facility” of modern ones would have 50,000 centrifuges.

Change of Topic

Recall that back in Note 6 on Risk, we discussed the “Linear No Threshold” assumption – the notion that, because we don't know how to determine the threshold below which a dose of a toxin becomes benign, we'll make the “safe” assumption that there is no such threshold. Congress grappled with this when, in 1958, it passed the Delany Clause. Delany prohibited the sale of foods containing *any amount of any known carcinogen* – a substance known to cause cancer. That sounds like a darn good idea, right?

Well, between 1958 and now the technology for measuring the composition of anything, including food, has gotten *much* better. We can accurately detect *much* smaller amounts of things, like carcinogens, than we could in 1958. In 1958, our tests might have said that a particular organic apple, for example, had no nitrites in it. Today, our tests would say, well, yes it does contain nitrates – but just a tiny, tiny little bit, and probably well below the threshold where it becomes benign for most people. The trouble is that most foods, even when carefully organically grown, have tiny amounts of almost everything imaginable in them. So a law that says “sell only food with absolutely no carcinogens”, is a law that says “sell absolutely no food”! That's probably not a good idea.

The Delany Clause was repealed in 1996 and replaced with a law that says that you can't sell foods containing an amount of a carcinogen that is known to cause cancer in at least one person in a million. Good change! The new law addresses the right question!

Concept: Sometimes you can have both precision and accuracy, and it still doesn't tell you what you want to know! Ask the right question!

Current testing technology will give you a precise *and* accurate measure of the composition of food, but that's not the real question. What you want to know is whether the carcinogen in it is above or below the threshold at which it can be considered benign.

By the way, you can find a lot of websites and advocacy groups, decrying the repeal of Delany. But, it's generally wise to be suspicious of policy positions with absolutes in them – words and phrases like “pure”, “containing no”, “free of”, “completely safe”, “100%”, and so on. As we said in the Note on Risk when talking about arsenic in drinking water – if you are willing to spend enough, you can get as close to perfection as you want, but you can't achieve it. *Nothing works perfectly. Nothing!*

We'll talk more about this in a later Note, but engineers often talk about the “Law of Unintended Consequences”. This isn't a scientific law or a legal one, but an observation about the world much like Murphy's Law (if anything can go wrong, it will). It says that in many cases the things we engineers design do what they were intended to do, but either (a) what they do didn't achieve the outcome we wanted, or (b) they did achieve the outcome, but they did more as well that we didn't intend, probably never thought about, and deeply regret in hindsight.

Consider the Interstate Highway System, especially around large cities. The idea was to relieve traffic congestion on city streets. What actually happened was to encourage urban sprawl, and to shift the congestion to the Interstates. Average travel times have not improved, and maybe have gotten worse. Or, consider the levees and dikes built along the Mississippi and Missouri River to prevent flooding in low lying areas, and hence to limit damage and loss of life. What actually happened was to encourage people to build homes and businesses in previously flood-prone areas and, when the “big one” came along, as it inevitable would, greater damage was done, and more lives lost as a consequence. Think Katrina!

Policies are at least as likely to suffer from unintended consequences as engineered systems. Most of the “loopholes” in tax policies, for example, are the result of not understanding the interaction of its many complex parts. Government rent control has sometimes led to housing shortages. In the wake of the Exxon Valdez oil spill, several western states passed unlimited liability laws for such spills, which lead at least one oil company to stop using its own fleet of modern tankers and contract with some far older, more spill-prone third-party tankers.

Policies with absolutes in them, like “absolutely no carcinogens” or “unlimited liability”, are especially prone to the Law of Unintended Consequences! It's undoubtedly more comfortable to live in a world with absolute assurances of things like health and safety, and politicians are into making their constituents feel good, so absolutes creep into many a policy discussion. But trying to achieve the unachievable never works, and the way it doesn't work is never anticipated by the advocates – that's not their focus.

Concept: Be suspicious of absolutes in policy!

By the way, the Law of Unintended Consequences doesn't always lead to bad outcomes. In the middle-ages most European countries had a policy of creating hunting preserves for the nobility. In our modern, more egalitarian time, that seems unfair. However, it had the unintended consequence of creating parks and “green space” for everyone today. The point is to be a critical thinker, not an advocate.