Guesstimate Gambit

Fermi Problems

A Fermi problem is an estimation problem designed to teach approximation of extreme scientific calculations in physics or engineering education. Fermi problems typically involve making justified guesses about quantities and their variance or lower and upper bounds. Such estimation problems are solved using a methodology which is informally called *back of the envelope* or *back of the napkin calculations.* In recent years, the term *Guesstimates* has also become fairly popular for defining such style of calculations. These terms are especially popular in the world of business. Other popular names for a Fermi problem are Fermi quiz, Fermi question, Fermi estimate, order-of-magnitude problem, order-of-magnitude estimate, or order estimation.

Enrico Fermi

Enrico Fermi was a great physicist who was well known for his ability to do approximate calculations with a very limited and sometimes no data at all. Hence, this estimation technique has been aptly named after him.

A popular example of his work is the estimation of the strength of the atomic bomb that detonated at the Trinity test. Enrico Fermi based his calculations on the distance travelled by pieces of paper he dropped from his hand during the blast. Surprisingly, his ballpark guess of 10 kilotons was quite close to the actual value.

The Fermi Paradox

Possibly the most famous Fermi Question is the *Drake Equation*, which seeks to estimate the number of intelligent civilizations in the galaxy. The basic question of why, if there were a significant number of such civilizations, ours has never encountered any others is called the *Fermi paradox.*

Advantages of Fermi Estimates

The premise of the Fermi estimates is that when individuals guess numbers and figures, their overestimates and underestimates help cancel each other out. That is, if there is no consistent bias, a Fermi calculation that involves the multiplication of several estimated factors will probably be more accurate than might be first supposed.

Scientists often look for Fermi estimates of the answer to a problem before turning to more sophisticated methods to calculate a precise answer. This provides a useful check on the results. While the estimate is almost certainly incorrect, it is also a simple calculation that allows for easy error checking, and to find faulty assumptions if the figure produced is far beyond what we might reasonably expect.

By contrast, precise calculations can be extremely complex but with the expectation that the answer they produce is correct. Without a reasonable frame of reference to work from it is seldom clear if a result is acceptably precise or is many degrees of magnitude (tens or hundreds of times) too big or too small. The Fermi estimation gives a quick, simple way to obtain this frame of reference for what might reasonably be expected to be the answer.

As long as the initial assumptions in the estimate are reasonable quantities, the result obtained will give an answer within the same scale as the correct result, and if not gives a base for understanding why this is the case. For example, suppose you were asked to determine the number of piano tuners in New York. If your initial estimate told you there should be a hundred or so, but the precise answer tells you there are many thousands, then you know you need to find out why there is this divergence from the expected result. First looking for errors, then for factors the estimation didn't take account of – Does New York have a number of music schools or other places with a disproportionately high ratio of pianos to people? Whether close or very far from the observed results, the context the estimation provides gives useful information both about the process of calculation and the assumptions that have been used to look at problems.

Although Fermi calculations are often not accurate, as there may be many problems with their assumptions, this sort of analysis does tell us what to look for to get a better answer. For the above example, we might try to find a better estimate of the number of pianos tuned by a piano tuner in a typical day, or look up an accurate number for the population of

New York. It also gives us a rough estimate that may be good enough for some purposes: if we want to start a store in New York that sells piano tuning equipment, and we calculate that we need 15,000 potential customers to stay in business, we can reasonably assume that the above estimate is far enough below 15,000 that we should consider a different business plan and, with a little more work, we could compute a rough upper bound on the number of piano tuners by considering the most extreme reasonable values that could appear in each of our assumptions.

So what are Guesstimates?

Guesstimate is the more popular term for Fermi Problems in the world of business. It is an informal English portmanteau of guess and estimate, first used by American statisticians in 1934 or 1935. Similar to the definition of Fermi estimates, guesstimate is defined as an estimate made without using adequate or complete information, or, more strongly, as an estimate arrived at by guesswork or conjecture. A guesstimate may be a first rough approximation pending a more accurate estimate, or it may be an educated guess at something for which no better information will become available. Guesstimation techniques are often used in the field of Information Technology where new development of features and release timelines are based on guesstimates of tasks.

The ability to make reasonable estimates is also essential in the field of consulting and thus something you are very likely to have to do in your case interview. You interviewer might ask something like:

How many sedans are sold in Germany in one year?

Our client wants to open a pizza place in New York. How many pizzas should he expect to sell on his first day of business?

How many people will buy the next model of iPhone when it hits the market?

The city of Bern in Switzerland is about to launch 'Bern on Cycle' program to boost tourism. How many cycles should they buy?

Chances are that you might be privy to the answers of a few of these questions. However, remember that the point of such questions is not to assess your knowledge, but rather to test your reasoning. When confronted with guesstimate questions during the recruitment or admission process, the idea is that you should work from what knowledge you have towards a sensible value.

Even though the word *Guesstimate* might tempt you to pluck the answer out of your imagination, remember that the idea is to be reasonable and make a judgement call which is based on logic. Even if you somehow got close to the real answer, your interviewer will not be impressed if you cannot demonstrate a sensible rationale for how you arrived at it. The winner will be the one who can demonstrate a capacity to reason.