Ravnoprochnost: Minimizing Uncertainties by Balancing Them

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Abstract

The engineering principle of balancing sturdiness of components within a design suggests we should avoid combining components of very different reliabilities. Doing so wastes well-made components in an assembly whose failure is governed by the poorly made components.

There is an analog of this principle in uncertainty analysis that arises in engineering decisions based on comparing imperfectly known quantities, such as the strength of a weathered structure against the stress placed on that structure. In many important cases, these comparisons are asymmetrically developed.

For instance, in cost–benefit analyses for environmental regulations, the benefits of regulation are estimated by sophisticated models accounting for variability within receptor populations and other kinds of uncertainty about data, yet estimation of the economic costs of regulation tends to be relatively simplistic, often relying on point estimates. Likewise, in toxicological risk assessment, exposure estimates are often carefully and specifically estimated but the threshold where organisms are expected to potentially experience harmful effects is more cursorily and generically estimated.

Such unbalanced comparisons are inefficient because overall the uncertainty can often be minimized by balancing the component uncertainties against one another. Expending disproportionate research effort on one side of a comparison is wasteful, because there are diminishing returns from reducing uncertainty due to sampling error in a single input of a two-component system.

We explore how a strategy that is more balanced can lead to clearer decisions and less wasteful decision making. We also explore how the balancing strategy should be adjusted to take account of differences in the ease of measurement to optimize the reduction of uncertainty in the assessment results. It may still be reasonable to estimate some pieces of an assessment with great precision even if the other pieces of the assessment have large uncertainties if those uncertainties cannot be reduced.