

## Sixth International Conference on Sensitivity Analysis of Model Output

**How to avoid a perfunctory sensitivity analysis**

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**Abstract**

The most popular SA practice seen in the literature is that of 'one-factor-at-a-time' (OAT). This consists of analyzing the effect of varying one model input factor at a time while keeping all other fixed. While the shortcomings of OAT are known from the statistical literature, its widespread use among modellers raises concern on the quality of the associated sensitivity analyses. We introduce a novel geometric proof of the inefficiency of OAT, with the purpose of providing the modelling community with a convincing and possibly definitive argument against OAT. Alternatives to OAT are indicated which are based on statistical theory, drawing from experimental design, regression analysis and sensitivity analysis proper.

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**1. Main text**

Mathematical modelers from different disciplines and regulatory agencies worldwide agree on the importance of a careful sensitivity analysis (SA) of model-based inference. In spite of these recommendations pointing to existing statistical theory based practices, most sensitivity analysis met in the literature even on the highest ranking journals are of a poor technical quality (Saltelli and Annoni, 2010).

The most popular SA practice seen in the literature is that of 'one-factor-at-a-time' (OAT). This consists of analyzing the effect of varying one model input factor at a time while keeping all other fixed. While the shortcomings of OAT are known from the statistical literature, its widespread use among modellers raises concern on the quality of the associated sensitivity analyses. We introduce a novel geometric proof of the inefficiency of OAT, with the purpose of providing the modelling community with a convincing and possibly definitive argument against OAT. Alternatives to OAT are indicated which are based on statistical theory, drawing from experimental design, regression analysis and sensitivity analysis proper.

We also investigate in this presentation another worked example of sensitivity analysis – that performed by Stern and co-authors in support to the cost benefit analysis underpinning the Stern Review of climate change policies. In fact we address both (a) the “Technical Annex to postscript” of the Stern review, which presents a sensitivity analysis (SA) addressing the conclusions of Stern review itself as well as (b) the debate on *Science* between Nicholas Stern and William Nordhaus. The purpose of the Stern's Annex is to defend with a SA a cost–benefit analysis (CBA) of climate change risk performed in the Stern review.

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Although the analysis performed by Stern and co-workers is definitely superior to the OAT approaches just discussed, we believe that SA has been used improperly in this application and that – had it been used properly – it would have falsified the analysis itself (Saltelli and D’Hombres, 2010). The same conclusions apply to Nordhaus’ critique in that both authors pretend to describe the issue on terms of parameters and models which bear no tested relation to reality.

This analysis brings us back to a discussion started exactly 20 years ago Saunders Mac Lane, a mathematician, on the quality of quantitative modelling which, for all purposes, could have been written today (Mac Lane, 1988a,b).

Then as today, the use of mathematical models in the absence of reality checks can be held responsible for a crisis of credibility in models. This crisis is popularized today by Nassim Nicholas Taleb (Taleb 2007) in Economics, and Orrin H. Pilkey and Linda Pilkey Jarvis in Environmental Sciences (Pilkey and Pilkey Jarvis 2007).

Among the reality checks which modellers are request to perform when going public with their findings, sensitivity analysis (SA) plays an important role, according to existing guidelines and textbooks (Office for the Management and Budget (OMB) 2002, 2006, European Commission (EC) 2009, Environmental Protection Agency (EPA) 2009, Kennedy 2007, Santner 2003, Saltelli et al. 2008).

It is evident that models’ use and misuse has technical as well as normative dimensions (Funtowicz and Ravetz, 1990). The recent ‘climate-gate’ and the mispricing of financial instruments leading to the crunch are but two examples of how in different forms and degrees modellers have sinned of omission or commission (Ravetz, 2010). Although sensitivity analysis is nothing more than a technique, if well performed it can go a long way to uncover problems of technical and -- possibly -- of normative nature.

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