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Joint Research Centre

Global sensitivity analysis: an introduction

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Motivation

- What (parameter, assumption, model spec's) drives the 'behaviour' of a model?
- How much a change in model factors (parameters, assumptions, model spec's) affects the 'behaviour' of a model?

Motivation examples

(i) Which parameters drive uniqueness of solutions or indeterminacy/unstable behavior?

(ii) Which parameters mostly drive the fit of, e.g., GDP and which the fit of inflation? Is there any conflict?

(iii) What is the 'shape' of the relationship between structural parameters and the solution of a DSGE model?

Introduction to GSA

Consider the computational model $Y = f(x)$

where x is a vector of input 'factors' $x = (x_1, x_2, \ldots, x_k)$

and Y is the output.

x_i **is the i-th element of x varying in** $0 \le x_i \le 1$

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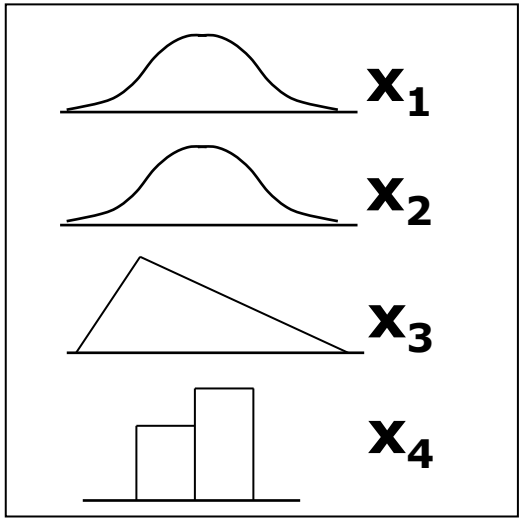
Specification of the input factors

$$x \in \Omega$$

Marginal p.d.f. $p(\vec{x}) = \prod p_i(x_i)$



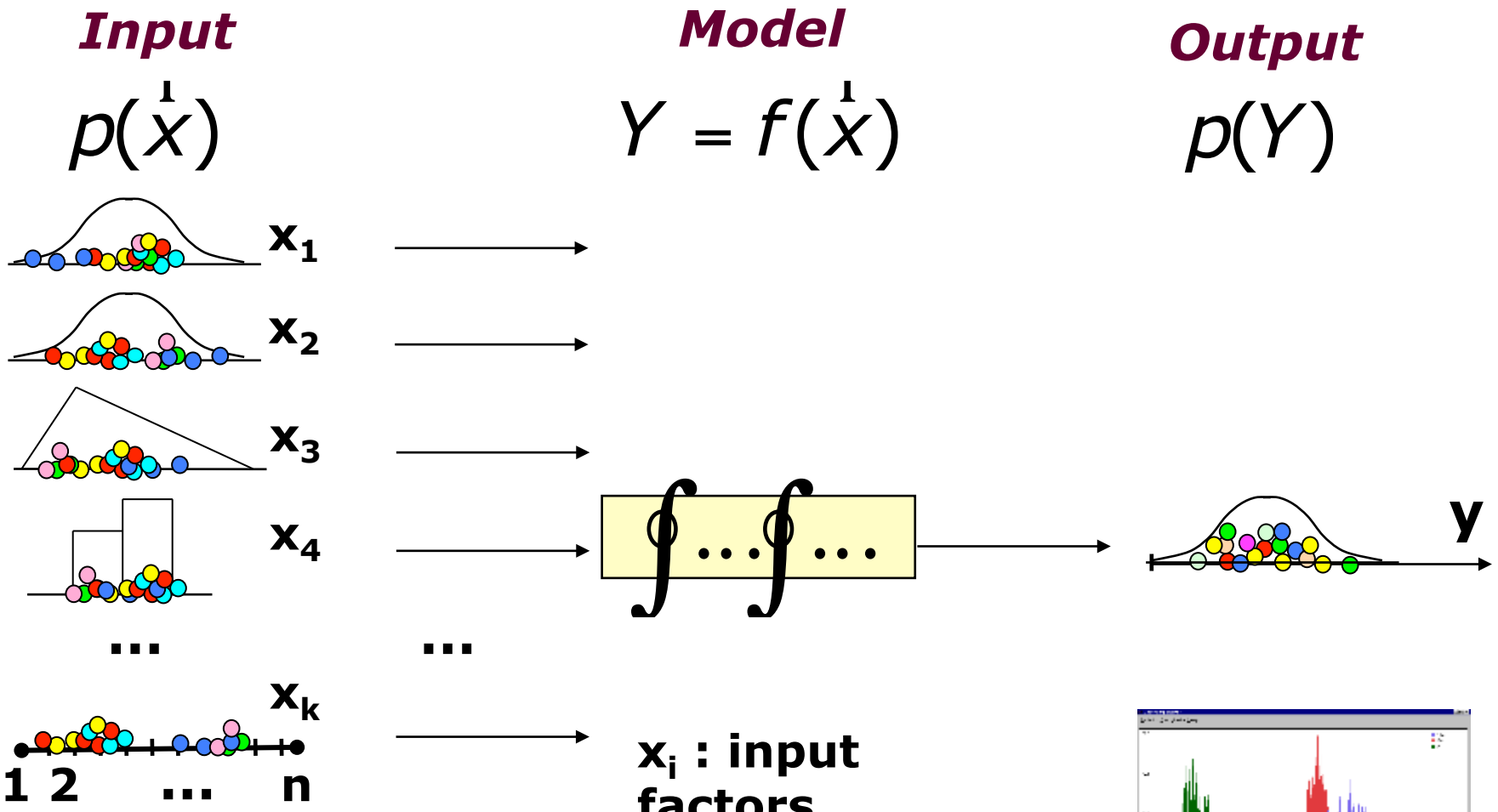
Marginal p.d.f. + correlation structure

Rank correlation, Dependence-trees, diagonal band, copulas

Joint p.d.f. $p(x_1, x_2, \ldots, x_k)$

MCMC (Gibbs, Metropolis, …)

Propagation of uncertainty



A GSA definition

Global sensitivity analysis: "The study of how the uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input"

One-at-a-time (OAT) methods for sensitivity analysis

One factor at a time methods are those whereby each input variable is varied or perturbed in turn and the effect on the output measured.

OAT methods

While OAT/derivatives are valuable for an array of estimation, calibration, identification, inverse problem solving, and related settings, their use in sensitivity analysis can be modest in the presence of finite factors uncertainty and non linear models.

OAT vs Global methods

Among practitioners of sensitivity analysis this is a known problem – non OAT approaches are considered too complex to be implemented by the majority of investigators.

Among the global methods:

various types of Monte Carlo filtering.

'meta-modelling' (smoothing methods or kriging) and variance based methods.

Further, sensitivity analysis can:

- surprise the analyst, find technical errors,
- gauge model relevance,
- identify critical regions in the space of the inputs, e.g. instabilities of a dynamical model
- help in estimation/calibration
- establish priorities for research, simplify models,
- anticipate (prepare against) falsifications of the analysis
- …