

Index

- Analytical g -function 123–7
ANOVA-HDMR decomposition 162,
213, 221, 274
Approximating functions
212–13
Asymptotic curves 57
- Batch reactor 262–70
see also Thermal runaway analysis
Bayesian model averaging 8–9
Bootstrapp 7–8
- Chemical reactor 262–70
see also Thermal runaway analysis
Clusters 58, 83
Composite index, *see* Composite
indicator
Composite indicator 240–53
aggregation methods 239, 241,
250–2
arithmetic v. geometric approach
239–40
baseline ranking 245–6
composite scores 244–5
and country rankings 242–3
cumulative shift 245, 246–7, 248
and elementary effects (EE) 239,
246–7, 252
input factors
impact 243–5
number reduction 246
and interactions 247
mapping 247–50
Monte Carlo Filtering (MCF)
248–50, 252
- behavioural/nonbehavioural
subsets 248, 249–50
robustness 241
Smirnov statistics 250–1
uncertainty analysis 242–3, 244
validity 241
variance-based methods 239,
246–7, 252
weights 247
Conditional expectation 160–1
Conditional variances 20–2
Continuous stirred tank reactor (CSTR)
as dynamical system 202
heat balance 201
mass balance 200, 201
stability conditions analysed
202–6
Hopf bifurcation locus 203–5
robustness check 204–6
Smirnov analysis 204, 205–6
uncertainties 206
Correlation ratio 213
Cost of analysis 17
‘Counterfeit Coin Puzzle’ 90–1
Cubic polynomial spline 218
- Data mining 54
Decomposition 160, 161–2
ANOVA-HDMR 162, 213, 221,
274
and risk 157
variance-based methods 19–20,
160, 161–2
Derivatives
advantages/disadvantages 11–12
as basis of sensitivity analysis 11

- Derivatives (*Continued*)
 compared with scatterplots 14–15
 normalization 15–16
- Deterministic models 157
- Deterministic regularization (DR) 218
- Discontinuous functional forms 57–8
- Discrepancy 83, 84
- Distribution of points 59–60
- Elementary effects (EE) 109–54
 advantages 127–8, 274, 275
 analytical g -function 123–7
 composite indicator application
 239, 246–7
 defined 110–11, 121
 and groups 121–2, 128
 role of delta (Δ) 120–1
 sampling strategy 112–16
 optimization 115–16
 sensitivity measure computation
 110–11, 116–22
 factor fixing 125
 practical example 123–7
 standard deviation 110, 111, 117
 test defined 38–9
- Endpoints 60, 62, 63–4
- Errors 15, 166
 standard error and uncertainty 59
see also type I errors, type
 II errors, type III errors
- Experimental design 35, 53–107
 group sampling 89–96
 and multiple parameters 64–89
 and single parameter 55–64
- Factor fixing (FF) 33–4, 125, 156
- Factor mapping (FM) 39, 40, 156–7,
 183–236
- Factor Prioritization (FP) 24–5, 156
- Factorial design, *see* Fractional factorial
 (FF) sampling
- Factors 5–6, 7
 distribution 10, 25
 in experimental design 54
 groups or sets 36–7
 identification 35
 independence 17
 influence 21, 24, 26, 27, 258–60
 and choice of technique 272,
 274–5
 and jumps in pricing options 257,
 258–60, 261, 262
 and Monte Carlo filtering 209–10
 nonindependent 41
 selection 9–10
- First-order effect 21
- First-order sensitivity index, *see*
 Sensitivity index, first-order
- ‘Fitness for purpose’ 4–5, 10, 43
- Fourier Amplitude Sensitivity Test
 (FAST) 159, 167
- Fractional factorial (FF) sampling
 71–6, 89, 274–5
 Hadamard matrix 73–4
 and LH sampling combined
 82, 106
 main effect (ME) of parameters 75
 and simulations 72
- Framingham Heart Study 53
- Fussell–Vesely measure 157
- g -function 123–7
- Gaps 58, 83
- Gaussian emulators 214–15
- Generalized Random Walk (GRW)
 222
- Group sampling 89–96
 number 92
 parameters
 allocation 92, 93
 influential 93, 94–6
 noninfluential 93–4
 sign variables 95, 96
 and simulations required 89
 stepwise analysis 95–6
 supersaturated designs 89–90
- Groups 36–7, 89–96
 and elementary effects method
 109–10
 and scatterplots 15
see also Group sampling
- Haar wavelet 216–18
- Hadamard matrix 73–4
- Halton sequence 84–6
 radical inverse transform 86
- Health studies 53–4
- High-dimensional model representation
 (HDMR) 160, 227, 228, 236
 estimating 214–24
 smoothing techniques (Haar wavelet)
 216–18
 spline smoothing 218–21

- state-dependent regressions 221–4, 227, 228
 - see also* ANOVA-HDMR decomposition
- Hodrick–Prescott (HP) filter 218–21, 223, 226
- Hopf bifurcation locus 203–5
- Index/indices, *see* Sensitivity index
- Infection dynamics
 - model 169–74
 - input factors 209–10
 - and Monte Carlo filtering 209–11
 - and Random Balance Design (RBD) 174
 - and sensitivity index 170–1
 - and uncertainty analysis 171
 - and variance-based methods 169–74
- Input factors, *see* Factors; Parameters
- Integrated Random Walk (IRW) 222, 223
- Interactions 30, 31, 268, 269, 272
 - definition 161
 - and metamodelling 274
 - in variance-based method 161–2
- Kennedy, Peter 42
- Kernel regression methods 213–14
- Kriging metamodells 214
- Latin hypercube (LH) sampling 76–80, 89, 103–5
- Leamer, Edward E. 9–10
- Least-square computation 17–18, 66
- Linear models 22–3
 - and experimental design 65–6
 - least-squares solution 17–18, 66
 - random samples 66
 - regression analysis 66
 - one-at-a-time (OAT) sampling 69
- Linear polynomials 57
- Linear regression 17–19
- Log-transformation 234
- Low-discrepancy sequence 83–9
 - defined 83
 - Halton sequence 84–6
 - see also* Quasi-random sampling
- Macroeconomic model 206–9
 - backward-looking/forward-looking components 207
 - Phillips curve 206–7
 - stability conditions 207, 208, 209
 - stable/unstable behaviour 207–9
- Main effect 75
- Mapping
 - Environmental Performance Index 247–50
 - factor mapping (FM) 39, 40, 156–7, 183–236
 - log-transformed functions 234
- Mean, as model output 157–8
- Mean estimates, stratified sampling 61–4
- Metamodelling 43, 183–236, 274, 275
 - approximating functions 212–13
 - interpolating 214–15
 - Gaussian emulators 214–15
 - kriging metamodells 214
 - kernel regression methods 213–14
 - methods summarized 212
 - and Monte Carlo Filtering (MCF) 184–211, 235
 - purposes 215
 - smoothing techniques 214–20
- Mirror points 69
- Model approximation 212–35
- Model coefficient of determination 19
- ‘Model-free’ approach 20
- Models 1–10
 - additive 23, 25
 - characteristics 277–8
 - deterministic 157
 - functions 4
 - inputs, *see* Factors; Parameters
 - linear, *see* Linear models
 - nonadditive 23, 25–9
 - nonlinear 19, 23
 - parameter estimation 6–10
 - parsimonious 43
 - relevance 34
 - Rosen’s 2
 - simplification 33–4, 35
 - and simulation requirements 89
 - types 5
 - unstable 128
- Modulus incremental ratios 45

- Monte Carlo Filtering (MCF) 39–40, 41, 184–211, 275
 behavioural/nonbehavioural subsets 39, 40, 184–6, 248, 249–50
 bidimensional projections 186–7
 and composite indicator 239, 248–50, 252
 continuous stirred tank reactor (CSTR) 200–6
 definition 184, 248
 implementation 185–7
 infection dynamics model 209–11
 macroeconomic model 206–9
 and metamodelling 184–211, 235
 parameter importance 185–6
 Regionalized Sensitivity Analysis (RSA) 184–5, 187–8
 Smirnov test/analysis 185–6, 187–8, 204, 205–6
 stability analysis 200–11
 Tree-Structured Density Estimation (TSDE) technique 188
 Monte Carlo method 6–7, 13, 16–20
 and first-order sensitivity measures 25–6
 and sensitivity index computation 164–7
 error estimates 166
 Multiple parameters 64–89
 Multivariate stratified sampling 80–2
 fractional factorial (FF) approach 81
 LH and FF approaches combined 82
 sample point generation 80–1
 Noise Variance Ratio (NVR)
 hyperparameter 222, 223
 Nonparametric R-squared 213
 Normalization 15–16, 56
 Null hypothesis 90
 Oakley–O’Hagan function 129, 130, 145–6
 One-at-a-time (OAT) sampling 66–9, 89, 109
 balancing 67–9
 parameter changes 69, 75
 Orthogonal arrays 79–80, 106
 Piecewise linear fit 62, 63
 Post-Normal Science (PNS) 4, 277
 Pricing options 253–62
 arbitrage-free prices 254
 Carr and Madan pricing method 256–7
 controllable/uncontrollable factors 257, 258–60, 261
 Cox–Ingersoll–Ross process 256
 Heston model 255–7
 input factors 257, 258–60
 jump parameters 258–60, 261, 262
 method selection 258
 risk 254–5
 strike price 254, 258, 260, 261
 uncertainty 255, 261
 volatility 262
 Pseudo-random generator 83, 100–1
 Quadratic polynomials 57
 Quantiles 119, 140
 Quasi-random numbers 274
 Quasi-random sampling 83–9
 and sample size 89
 Sobol’ LP₇ sequence 87
 testing 86–7
 uncertainty estimates 89
see also Low-discrepancy sequence
 Radical inverse transform 86
 Random Balance Design (RBD)
 167–9, 274
 advantages/disadvantages 168–9, 236
 and infection dynamics 169–74
 procedure 167–8
 Random samples 58–9, 66
 pseudo-random generator 83, 100–1
 Regionalized Sensitivity Analysis (RSA)
 184–5, 187–8
 limitations 188
 Regression coefficients 18
 Regression methods 17–18, 37, 66, 213–14, 274
 Regularization 218
 Residuals 66
 Resolution III 74
 Resolution IV 74, 103, 107
 Risk decomposition 157
 Risk reduction worth 157
 Rosen, R. 2

- Saltelli's method 164–7, 236, 272, 274
- Sample matrices 274
- Sampling strategy
 - and elementary effects 112–16
- Scatterplots 13–14, 15
 - and derivatives 14–15
 - point interpolation 37
 - shape or pattern 21
 - slicing 21–2, 23
 - smoothing 216–18
- Sensitivity analysis
 - cost of 17
 - definition 1
 - global v. local 11–12, 35–6
 - graphical presentation 271–2
 - methods 10–40
 - practical applications 237–75
 - problems 41–2
 - purposes 11, 34–6
 - set-up considerations 237
- Sensitivity measure 21
 - applied to linear model 22–3
 - computation 164–9
 - acceleration 38
 - FAST method 167
 - from smoothed estimates 224–9
 - Haar wavelet smoothing 225–6
 - method choice 235–6
 - Monte Carlo procedure 164–7
 - RBD 167–9
 - Saltelli's method 164–7, 236
 - spline smoothing (HP filter) 226
 - computational cost (CPU time) 272
 - defined 21
 - for the elementary effects method 110–11, 116–27
 - first-order 21, 24, 25–6, 28, 30, 37
 - methods compared 173
 - Monte Carlo computation 164, 165
 - suitability 275
 - and variance 161
 - higher order 29–31
 - and infection dynamics 170–1
 - and Monte Carlo method 25–6
 - properties 166–7
 - second order 30
 - variance-based 258, 261
- Sensitivity measures
- Sensitivity pattern 33
- Sensitivity tests
 - settings 155–7
 - Factor Fixing (FF) 156
 - Factor Mapping (FM) 156–7
 - Factor Prioritization (FP) 24, 156
 - Variance Cutting (VC) 156
- Sets, *see* Groups
- Settings 10–40
 - definition 24
- Simulations 89
 - and fractional factorial (FF) sampling 72
 - group sampling 89
 - and models 89
 - number determined by parameters 92, 102–3
- Slicing 21–2, 23
- Smirnov test/analysis 185–6, 187–8, 204, 205–6, 250–1
- Smoothing techniques 214–20, 235
 - examples 224–9
 - SDR techniques 221–4, 226–7
 - spline smoothing 218–21, 223
 - using Haar wavelet 216–18, 225–6
- Sobol', I. M. 160
- Sobol' procedure 87, 266–7, 268, 272
- Spline smoothing 218–21, 223
 - Hodrick–Prescott (HP) filter 218–21, 226
 - 'trend' 220
- Stability analysis
 - continuous stirred tank reactor (CSTR) 200–6
 - infection dynamics model 209–11
 - macroeconomic model 206–9
- Standard error 59
- Standardized regression coefficients (SRCs) 18, 26, 274, 275
- State-dependent parameter (SDP) and HDMR 221–2
- State-dependent regression (SDR)
 - approach 214, 221–4, 226–7, 235, 236
 - advantages/disadvantages 223, 236
 - and HDMR 227, 228
- Stratified sampling 59–61
 - mean estimates 61–4
 - multivariate 80–2
 - point distribution 59–60
 - variance estimates 61–4
- Supersaturated designs 89–90

- Taylor rules 201–2
- Thermal runaway analysis 263–70
 - ANOVA-HDMR terms 268, 269, 270
 - interactions 268, 269
 - metamodelling 266
 - method choice 266
 - procedure 266–9
 - runaway/nonrunaway conditions 264, 265
 - Semenov number 265
 - Sobol' procedure 266–7, 268
 - and state-dependent parameter (SDP) 266, 268
 - temperature behaviour 266–9
 - uncertainty distributions 264–6
- Total effects 112, 162–3, 173, 275
 - estimation 164, 165, 236
 - and sensitivity pattern 33
 - terms 31–3
- Total indices, *see* Total effects
- Total sensitivity index
 - definition 112
 - see also* Total effects
- Total System Performance Assessment (TSPA) 278
- Tree-Structured Density Estimation (TSDE) technique 188
- Type I errors 15, 177
- Type II errors 42, 177, 277
 - definition 15
 - protection against 35, 36
- Type III errors 15, 42, 278
- Uncertainty 1, 3–7, 35, 157–8
 - and chemical reactor 262
 - and composite indicator scores 242–3, 244
 - and groups 36–7
 - graphical presentation 271
 - and infection dynamics 171
 - input factors 8
 - and jumps in pricing options 255
 - quantification 158
 - and standard error 59
 - 'Uncertainty importance' 159
- Uncertainty–sensitivity plot 270–2
 - purposes 271–2
- Variables, *see* Factors; Parameters
- Variance-based methods 37–8, 155–82
 - advantages 157–8
 - and composite indicator 239, 246–7, 252
 - decomposition 19–20, 160, 161
 - disadvantages 158, 174
 - first-order variance term 159
 - Fourier Amplitude Sensitivity Test (FAST) 167
 - historical aspects 159–61
 - infection dynamics model 169–74
 - and interaction effects 161–2
 - Random Balance Designs (RBD) 167–9
 - sensitivity index computation 164–9
 - settings 155–7
 - total effects 162–3
 - uncertainty measurement 158
- Variance cutting (VC) setting 45, 156
- Variance estimates 61–4
- Yucca Mountain repository for radioactive waste disposal 278