

Index

- AAU, see Assigned Amount Unit
Acid Rain Program 46
additionality 42–3
ADF test, see augmented Dickey–Fuller (ADF) test
All Publications Index (API) 21
American option 66, 77, 289
Amsterdam–Rotterdam–Antwerp (ARA) 4, 9, 20–2
Anglo American 20
ANN, see artificial neuronal network
annuity 183
antithetic paths 289–90
API, see All Publications Index
AR(p) model 277
ARA, see Amsterdam–Rotterdam–Antwerp
arbitrage 47, 49, 57, 77, 89–90, 94, 108, 117
ARMA(p, q) model 119, 121, 277
artificial neuronal network 229
Asian option 66
 log-normal approximation 68–72
 Vorst method 67
asset book 259
asset pricing 94
 fundamental theorem 94
Assigned Amount Unit (AAU) 43
augmented Dickey–Fuller (ADF) test 278
Australia 14, 17–21, 24, 26, 38–9
autocorrelation function 127–8, 278
autoregressive model 277
autoregressive moving average model 277
- B2B, see Business-to-Business
B2C, see Business-to-Consumer
backtesting 201, 263–4
backward iteration 85–6
backwardation 91, 97, 102
- BAFA index 23
balancing
 market 29–33
 period 27–8, 30, 205
 power 33, 132, 217, 222–4, 231–5, 242
banking
 CERs 43, 45
 EUAs 40
Barings Bank 265
Basel Committee 252
baseload contract 25, 30–1, 35–6, 114–16, 126–7, 138, 217–18, 222, 226, 247, 249
 prices 25
basis risk 51
basket option 70–2
Bellman 156–7, 159
Bertrand model 193
BHP Billiton 19
bid curve 176, 294
Big Four 19
binary variable 155–6, 164
binomial tree 66
Black model 55, 62–3, 109
block contract 30–1
borrowing
 EUAs 40
Brent
 21-day forward 7–8
 BFO index 7
 Contract for Differences (CFD) 7
 dated Brent 7–8
brown coal, see lignite
Brownian motion 109, 111, 128, 241, 255–6, 284–5
Bundesverband deutscher Banken 267
Burden Sharing Agreement 39–40
Business-to-Business (B2B) 225–6
Business-to-Consumer (B2C) 225, 227

- cap-and-trade 46
 cap 77–80
 capacity payment 135
 Cape size vessel 22
 carry forward 207–8
 Cashflow-at-Risk (CFaR) 264–5
 CCGT, see combined cycle gas turbine
 CCX, see Chicago Climate Exchange
 CDM, see Clean Development Mechanism
 Central Appalachian 20–1
 coal futures 21–2
 coal 20
 central counterparty 3, 51
 CER, see Certified Emission Reduction
 Certified Emission Reduction (CER) 42–6, 216
 change of numeraire 75
 Chicago Climate Exchange (CCX) 46
 China 1, 17–18, 22–3, 43
 CHP, see combined heat and power
 CIF, see Cost, Insurance and Freight
 CITL, see Community Independent Transaction Log
 Clean Development Mechanism (CDM) 38, 42–3
 clearing 34–6, 51
 CO₂
 emissions market 37–46, 215–16
 equivalent 38
 exchanges 44
 market model 216
 production factor 142
 volatility 44
 coal
 freight 22
 index 21, 222
 market model 215–16
 power plant 17, 25, 72, 137, 182, 190, 216
 quality 16, 137, 216
 reserves 17–18
 swap 21
 trading 18, 20–2
 cointegrated 129
 cointegration vector 129–30
 coking coal 16–17, 23, 216
 collateralisation 268
 combined cycle gas turbine (CCGT) 137–8, 142, 175, 182, 197
 combined heat and power (CHP) 138, 140, 142, 145, 150, 169, 198
 Community Independent Transaction Log (CITL) 40–1, 201
 complementary error function 57
 complete market 92, 94, 202
 composite option 73–5
 conditional expectation 235, 284, 287–8
 conditional VaR 251
 confidence level 251–3
 constraint
 binary 145, 155, 164
 capacity 34, 145–6
 combined heat and power 150–1
 minimum load 180, 199
 reserve 149–51, 173–4
 start-up 145–6
 time-integral 150, 156, 159, 165, 175, 180–1, 199
 transmission 178–9
 consumption
 electricity 23–4, 132, 144
 consumption asset 89–90
 contango 91, 97, 102
 contract for difference 7, 34–5, 192
 control variate 67, 290
 convenience yield 74, 89–94, 97
 Cornish–Fisher expansion 258
 correlation
 estimating 261–3
 matrix 71, 129–130, 257–9
 price–volume 231, 235–7, 240, 242
 skew 63, 71
 cost 4, 143, 147–8, 198–200, 232
 investment 19, 89, 138, 141, 182, 202, 207
 start-up 145–6, 148–9, 175, 180, 199
 variable 145–7, 160, 162, 176, 186, 199–200, 207, 216
 Cost, Insurance and Freight (CIF) 4
 Cournot 193–5
 behaviour 194
 equilibrium 194–5
 model 193–4
 covariance-stationary process 277
 covered call 54
 Cox–Ingersoll–Ross model 110
 crack spread 72
 cracking 8
 credit rating 269–73
 credit risk 48, 51, 231, 235, 242, 265–9
 exposure 266
 credit VaR 268
 crude oil 3–9, 88, 215

 dark spread 69, 72
 dated Brent 7–8
 day ahead market 28, 31, 34–5, 151, 154
 decision theory 187
 decomposition 162–3, 165, 212, 227
 default probability 270–1
 delta-gamma method 254, 258
 delta neutral 58, 60
 delta-normal method 254–7

- delta position 218, 225, 228, 244–9, 254, 257–9
- demand
 - elasticity 44, 135, 176, 195
 - electricity 24, 118, 132–4, 139, 142, 178, 190, 197, 205
- Deutsche Rahmenvertrag 267
- Dickey–Fuller (DF) test 278
- diesel 8, 9
- dispatch
 - hydro power plant 151–5
 - pattern 136–7
 - power plant 136, 143
 - thermal power plant 145–51
- duopoly 193
- duration curve
 - load 167–9, 172
 - price 164, 167, 172–7
- dynamic hedging strategy 60, 62
- dynamic programming 85, 156–61, 165

- Earnings-at-Risk (EaR) 264, 265
- economic dispatch 143
- ECX, see European Climate Exchange
- EEX, see European Energy Exchange
- EFET, see European Federation of Energy Traders
- elasticity
 - CO₂ 44–5, 216
 - electricity 135–6, 176, 195
 - gas 205
- Elbas 34
- electricity
 - characteristics 27
 - consumption 23, 132
 - exchanges 33
 - prices 25–6
- Elspot 34
- emission reduction purchase agreement (ERPA) 45
- Emission Reduction Unit (ERU) 42–3, 45, 216
- emission
 - allowance 25, 35, 40, 43–4, 70, 125, 142, 199
 - exchanges 44
 - limit 38–9, 145
 - market 37
 - market model 215–16
 - trading
 - European Union 38–9
 - North America 46
 - SO₂ 46
- ENDEX 14, 33
- energetic hedging 239–40, 250
- energetic position 218, 225–7, 238, 244, 247–9
- Energy Exchange Austria (EXAA) 33, 44

- Enron 265
- equilibrium
 - Cournot 194–5
 - Nash 191–5
- equivalent martingale measure 93–4
- ERPA, see emission reduction purchase agreement
- ERU, see Emission Reduction Unit
- ETSO, see European Transmission System Operators
- EU ETS, see European Emissions Trading Scheme
- European Banking Federation 267
- European Climate Exchange (ECX) 4, 44
- European Emissions Trading Scheme (EUETS) 39–40, 142, 216
- European Energy Exchange (EEX) 33, 35–6, 44, 63, 114, 268
- European Federation of Energy Traders (EFET) 267–8
- European option 57, 66, 288
- European Transmission System Operators (ETSO) 31–2, 201
- EXAA, see Energy Exchange Austria
- exchange 3–4, 33, 44, 51
- exchange option 72
- exercise strategy 66, 77–8, 81, 86
- expansion
 - capacity 182–4
 - gas supply 214
- expected loss 235, 267, 270–1
- exponentially weighted moving average 261–2
- extensive form 190

- fair value 47–50, 92
- Feynman–Kac theorem 287
- financial settlement 3, 51
- finite-difference method 66
- flexible mechanisms 38, 42–3, 46
- floor 78
- FOB, see Free on Board
- forecast
 - electricity price 202–3
 - load 201, 228–30
 - wind power 202
- Forrester 184
- forward contract 3, 48–50
 - crude oil 7
 - electricity 30, 192–3
- forward curve 108–13
 - electricity 114–17
- forward iteration 86
- forward price 48–50, 88–91
- France 25, 36, 39, 132, 134, 139, 142, 205–6, 227

- Free on Board (FOB) 4
 fuel market model 215
 fuel oil 8, 138, 245
 fuel switch 25, 206, 216
 full service contract 220
 fundamental theorem of asset pricing 94
 funds from operations 272
 futures contract 3, 51, 192
 cascading of 31
 CO₂ 44
 crude oil 7
 electricity 30, 192
 natural gas 12

 game theory 186, 190–5, 215–16
 game
 non-zero-sum 191
 GARCH model 262
 gas 9, 204, 245
 demand 205
 market model 204–15
 portfolio optimisation 205
 power plant 23, 137
 quality 206
 storage 210
 supply 206
 transport 208
 gas turbine (GT) 138, 174, 197
 gasoil 138, 245
 gasoline 8
 generation pattern 136–7, 170
 Geometric Brownian motion 95, 256
 Germany 18, 30, 35, 39–40, 132, 138, 140, 227
 GH0 profile 30
 Girsanov's theorem 93
 Glencore 20
 globalCoal 22
 Greeks 57
 greenhouse effect 37
 GT, see gas turbine

 hard coal 16
 Health–Jarrow–Morton (HJM) theory 108
 heating oil 8
 hedge ratio 247, 249
 Henry Hub 3, 12
 heuristic 163–4, 172
 HJM theory, see Health–Jarrow–Morton (HJM) theory
 holding period 238, 252
 hourly forward curve 114–17
 hurdle rate 238, 241
 hydro power plant 23, 25, 139, 151, 161, 169, 171
 hyperbolic distribution 130

 ICE, see Intercontinental Exchange
 IET, see International Emissions Trading
 IETA, see International Emissions Trading Association
 incomplete market 94
 Incoterms 4
 indexed contracts 135, 221
 gas 207
 hedging 227
 oil price 245
 India 17
 inner value 55, 58
 integrated process 278
 interconnection 143, 175, 179, 200
 interconnector 12
 Intercontinental Exchange (ICE) 3, 22, 36
 interior point 155
 international commerce terms, see Incoterms
 International Emissions Trading (IET) 42–3
 International Emissions Trading Association (IETA) 267
 International Panel on Climate Change (IPCC) 37
 International Petroleum Exchange (IPE) 3
 International Swaps and Derivatives Association (ISDA) 267
 interruptible contract 135, 209, 225
 intra-day market 28, 31
 intrinsic value 78
 investment 182–4, 214
 investment asset 89
 IPCC, see International Panel on Climate Change
 ISDA, see International Swaps and Derivatives Association
 Italy 41, 138, 141–2, 206
 Itô calculus 285
 Itô process 286
 Itô's Lemma 286

 Japan 21, 43
 Japanese Crude Cocktail 14
 jet fuel 9
 JI, see Joint Implementation
 Joint Implementation (JI) 38, 42
 jump diffusion model 63

 kerosine 8
 Kyoto Protocol 37–9
 flexible mechanisms 42

 Lagrange 162
 legal risk 266
 lignite 16, 24, 138, 198
 power plant 138
 linear programming (LP) 84–5, 155, 178, 215

- linear regression 229–30, 275
liquefied natural gas (LNG) 10, 15–16, 206
 plant 15
 regasification terminal 15, 206, 214
 vessel 15
liquefied petroleum gas (LPG) 8
LNG, see liquefied natural gas
load
 curve 132, 134
 data 196
 forecast 228–30
 minimum 145, 199
load balance equation 151, 154, 179
load duration curve 167, 169
load profile risk 221
long-term gas contract 207, 213
LP, see linear programming
LPG, see liquefied petroleum gas
- MA(q) model 277
margining agreement 268
Margrabe formula 72
marked-to-market valuation 47–8
market clearing price 131, 215
market power 187
 mitigation 192
market price
 exposure 243
 risk 218, 251, 265
 sensitivity 248, 258
market price of risk 88, 98, 102
Markovian process 285
martingale 93–5, 108, 284
MCP, see mixed complementary problem
mean reversion 87, 100, 114
Mediterranean 9
merit order curve 113, 118, 166–76, 187–9, 194
methane 9, 37–8
middle distillates 8
minimum downtime 146, 159, 175, 199
minimum uptime 146, 159, 175, 199
MIP, see mixed integer programming
mixed complementary problem (MCP) 195
mixed integer programming (MIP) 145, 155, 178, 215
moneyiness 71
Monte Carlo simulation 66, 288
 antithetic paths 289
 control variate 290
 variance reduction 289
Moody's 269
moving average model 261
multi-commodity 125–30, 204
multi-region 175, 179, 216
municipalities 226, 228
NAP, see National Allocation Plan
naphta 8
Nash equilibrium 191–4
National Allocation Plan (NAP) 40–5, 216
National Balancing Point (NBP) 12
National Grid Transco 36
natural gas 9, 204, 245
 market model 204–15
 power plant 137
NBP, see National Balancing Point
net transfer capacity (NTC) 180, 201
Netherlands 12, 25, 33, 43, 138, 206
new entrants reserve 40
New York Mercantile Exchange (NYMEX) 3, 7, 12, 20–1, 30, 36
Newcastle 20–2
Nord Pool 33–5, 44, 135
normal distribution
 cumulative distribution function 56–7
 density function 60, 237
normal form 190
Norway 12, 24–6, 34, 206
NTC, see net transfer capacity
nuclear
 phase-out 138
 power plant 24–5, 43, 138, 200
NYMEX, see New York Mercantile Exchange
- objective function
 gas portfolio 212
 hydro dispatch 181
 thermal dispatch 151
offer curve 131–2, 175–8, 188–9
offer strategy 188
oil
 consumption 4–6, 9
 market model 215–16
 power plant 8, 138
 production 4–6
 refined products 9
 reserves-to-production ratio 5, 8
 reserves 5–6
 sour crude 6
 sweet crude 3, 6
oligopoly 192
OPEC 5, 8, 11, 216
operation cost
 variable 25, 138, 147, 166, 199
operation variable 145–6
operational risk 231, 240–1, 243
operations research 155
optimisation 77–8, 81–2, 155–66, 178–83, 212

- option 8, 63–76
 - American-style 66, 91
 - Asian 66–9, 288, 290
 - call 53
 - cap 77–8
 - CO₂ 70
 - crude oil 7
 - delta hedging 57–8
 - delta 58
 - electricity 60, 63
 - European-style 53, 55
 - floor 78–80
 - gamma 60
 - intrinsic value 78
 - natural gas 12
 - path-dependent 66
 - put 53
 - swing 80–3
 - theta 59–60
 - time value 58–9
 - vega 61–2
 - virtual storage 83–5, 155, 210
- Orimulsion 138
- OTC, see over-the-counter
- over-the-counter (OTC) 3

- Panamax vessel 22
- path-dependent option 66
- payer swap 53
- PDE solvers 66, 289
- peakload contract 30–1, 116, 218, 222, 240, 247
- peat 138
- petroleum 4
- PJM hub 36
- point of delivery 4, 20
- portfolio
 - gas 205–7, 212
 - management 223–4
 - sourcing 218–19
- potential exposure 267
- power plant
 - coal 137, 182, 190, 216
 - conventional thermal 137–8, 197–9
 - dispatch 143–5
 - gas 138, 205–6, 216
 - hydro 139–40, 143, 151–4, 169–72, 200
 - investment 186
 - lignite 138, 198
 - nuclear 138, 200
 - oil 138
 - renewable 140, 200
 - thermal 145–51
 - virtual 47, 222
- power schedule 30, 218–19, 247–50

- PowerNext 33, 44
- price drivers
 - electricity 25, 132
 - supply side 141–3
- price duration curve 164, 167, 172–3, 176–7
- price elasticity
 - CO₂ 216
 - electricity 135, 197, 216
 - gas 205
- price peaks 176, 203
- price profile risk 124, 219
- principal component analysis (PCA) 120–1, 279
- Profit-at-Risk (PaR) 238, 252, 264–5
- protective put 54, 80
- pumped storage 27, 136, 139, 143, 169–70
- put–call parity 53–4

- qq-plot 254
- quanto option 73, 75–6

- ramp rate 146–7, 159, 199
- RAROC, see Risk Adjusted Return on Capital
- rating
 - agency 271
 - external 269–70
 - internal 271–3
- real-time market 29
- receiver swap 53, 64
- recovery rate 267, 271
- refinery 6
- Regional Greenhouse Gas Initiative (RGGI) 46
- regression
 - forecast 229
 - linear 275
 - OLS 275
- regressor 275–6
- renewables 126, 140–1, 200
- replacement risk 265–9
- reserve
 - coal 17
 - contract 224
 - market 29–30, 143
- reservoir balance equation 153, 171
- residual demand curve 188–90, 195
- retail contract
 - full service 220–1
 - indexed 221–2
 - interruptible 225
 - partial delivery 222
 - right of cancellation 225
- return
 - continuous compounding 256
 - daily 259, 261, 263
 - on equity 272

- RGGI, see Regional Greenhouse Gas Initiative
 Rheinschiene HEL/HSL oil price 9
 Richards Bay 4, 20–2
 Rio Tinto 19
 risk
 definition of 250
 electricity price 203
 factor 92–4, 129–30, 247, 253, 263
 map 243
 premium 230–41
 Risk Adjusted Return on Capital (RAROC)
 224, 235, 238, 241
 risk-at-default 267
 risk-neutral measure 55, 92–5, 108
 RiskMetrics 262
 Russia 10, 12, 17, 18, 43, 206, 214

 scarcity 176–8
 scenario
 analysis 164, 265
 reduction 165, 181
 Schwartz model 100–2
 Schwartz–Smith model 103–8
 SCoTA, see Standard Coal Trading Agreement
 seasonal pattern 87, 91, 114, 132, 170, 198,
 205, 228–9, 263
 settlement risk 265–6
 similar-day approach 229–30, 234
 Simplex 155
 SMaPS model 117–20, 236, 239–40,
 250, 265
 SO₂ emissions trading 46
 South Africa 17–20, 25–6
 Spain 25–6, 39–41, 43, 132, 138, 206
 spark spread 72
 spot market
 CO₂ 142
 electricity 27, 31, 35, 76–7, 91, 114,
 117–22, 202
 gas 76
 spot transaction 3
 spread option 72–3
 stack model 166
 Standard Coal Trading Agreement (SCoTA)
 22
 start-up 148–9
 cost 142, 145–6, 148–9, 176, 180, 199
 stationary process 277–8
 steam coal 17, 19, 23, 216
 stochastic differential equation 286–7
 stochastic process 277, 283
 stochastic programming 164–5, 212
 stochastic-volatility model 63
 storage
 gas 210–12
 Sullom Voe 7

 supply
 electricity 136, 197
 gas 206–8
 swap
 commodity 3, 52–3
 crude oil 48
 fixed leg 53
 floating leg 53
 gasoil 9
 payer swap 53, 64
 receiver swap 53, 64
 swaption 64–5
 swing 80, 207
 system dynamics 184–6, 215
 system expansion 182, 184, 214, 215

 take or pay 16, 142, 145, 150, 175, 199,
 207–8
 tangible net worth 272
 Taylor series 62, 254–5, 258
 time horizon 252
 time series models
 forecasting 229
 Title Transfer Facility (TTF) 12
 transfer capacity 180, 201
 transmission system operator (TSO) 27–8
 transmission 143, 180, 200
 trend-stationary process 278
 trinomial tree 66
 TTF, see Title Transfer Facility

 UCTE, see Union for the Co-ordination of
 Transmission of Electricity
 UNFCCC, see United Nations Framework
 Convention on Climate Change
 Union for the Co-ordination of Transmission of
 Electricity (UCTE) 32, 173–4, 196, 201
 United Kingdom 18, 25–6, 36, 39–40,
 141, 206
 United Nations Framework Convention on
 Climate Change (UNFCCC) 38
 United States 3, 10, 12, 17–18, 20, 22–6, 39, 46

 Value-at-Risk (VaR) 250–8
 analytical method 253, 255
 backtesting 263–4
 delta-gamma method 254
 delta-normal method 254–8
 historical simulation 253, 265
 liquidity adjusted 258–61
 Monte-Carlo method 256
 VaR, see Value-at-Risk
 variance minimising hedging 249–50
 variance reduction 289
 variation margin 30, 51
 Vasicek model 100–1

virtual power plant 47, 222

virtual storage 83–5

volatility

CO₂ emissions 44

estimating 261–2

volatility skew 63, 71

volatility smile 62–3

volume risk 231, 236, 239–40, 242

water values 170–1

weather 76, 114, 134, 142, 196, 202, 230

wind power 140, 168–9, 203

Xstrata 20

Zeebrugge 12–14

