Index

abatement costs 37, 39, 43, 45, 47–52
equity issues in 39, 48–52
types of 39, 48–9
welfare distribution and 47, 48
see also emission control/reduction
ability to pay principle 47, 48
Acidification indices 18–82
see also emission impact indices
acoustic pollution 145
aggregation methods see linear aggregation
air pollution 145
airport landing networks 113
Alesina, A. et al. 66, 85
Algeria 111
allocation-based costs see cost allocation
Antonioli, B. et al. 135
asbestos 146
ASTM S.p.a. 134–5
Aumann, R. 225

bankruptcy, cost sharing in 117
Barrett, S. 62, 66
Başar, T. 90, 108
Bertrand game 232
bioeconomic models 187–9
Bischi, G.I. 187, 188, 202, 208
Bloch, F. 225
Borch, K. 146–7
Borm, P.E.M. 149
Botteon, M. 52
Buchner, B. et al. 66
Bulow, J. et al. 226, 240
burden-sharing see equity issues
bus games 137

carbon cycle 41
see also emission control/reduction
Carraro, C. 39, 52, 62, 66, 74, 85
case studies

commercial fisheries 187–8, 190
resource exploitation 5, 187–211
waste collection 125–44
Cesar, H. 54–6
Chandler, P. 10, 17, 23, 26, 27, 31, 35, 43, 52, 62, 225, 246
Charnes, A. et al. 175
China 42, 45, 53–7
Ciscar, J.C. 87–8, 107, 108
Clarke, F.H. et al. 222
climate change 37, 41, 87
acid rain 108
see also environmental issues
climate policy
coordination of 88–9
domestic level 9–10
game theory and 9–110
global agreements 52–8
international agreements see international agreements
Kyoto Protocol see Kyoto Protocol
profitability issues 22–3, 58, 39–40, 46–52
regional agreements 40
self-enforcing agreements 38
stability of 38, 39–52, 61
time consistency of 87–8, 92–106, 107
on transfrontier pollution 9–36, 37
coalition formation 42–3
cost sharing see cost sharing methods
decision making and 9, 224–45
delta rule of 35, 246
game theory and 2–3, 4, 9, 10, 11–36, 37, 38, 65, 67–85, 225–6
issue linkage 2–3, 65–86
joint projects see joint projects
Kyoto Protocol see Kyoto Protocol
multiple 40, 45, 50
ratification constraints 9–36
Index

single 40
stability in 40, 46–52
see also cooperative games
coalition paradigm 90
coalition rationality 150–51
Cobb-Douglas production function 41, 191, 240
Cobb-Douglas utility function 240–45
co-insurance games 146, 150–53
commercial fisheries 187–8, 190
see also resource exploitation
compensation principle 48
competitive behaviour, emission trading as 212–23
conjectural cooperative equilibrium (CCE) 5, 226–40
Cobb-Douglas utility function in 240–45
strategic complementarity in 239–40
conjecture formulation, in cooperative equilibria 225
consensus criteria 49
consumption activities
cost sharing and 4, 164–84
definition 164, 173
effects of 164, 166, 172–4, 176–83
emission indices 176–83
environmental impact 4, 87, 164–84
convex games 115–17
cooperative equilibrium 79–83, 224–45
conjecture formulation in 225
definition 224, 225
cooperative games 2–3, 4, 11–36, 120–21, 136–42
core concept 9, 19
gamma core 35
in cost sharing 114–24
delta rule 35, 246
full cooperation 9, 188, 189, 190–93, 200–207, 208–9
non-cooperative 38, 65
three-stage 67–85
unilateral defection 187, 188–9, 190–93, 200–207, 224–45
partial agreement equilibrium (PAE) 22–3, 31, 33
see also coalition formation
core concept
gamma core 35
in game theory 9, 19, 137–8, 139–40, 150–51, 215–15
the nucleolus 139, 140
Cornilie, J. 62
cost allocation 4, 46–7, 136–42, 164, 166
direct costs 170, 173
Kantian allocation rule 47, 49
multiple 166, 168–72
one-dimensional 4, 138–42
polluter pays principle 47
random order 165
vector 4, 164–5, 168–74, 177, 183
cost sharing methods 4
accounting for 166, 168–72
in bankruptcy 117
common in practice rule 138
consumption activities and 4, 164–84
cost allocation see cost allocation in environmental insurance 4, 145–63
game theory and 113–84
in joint projects 3–4, 113–24
in taxation systems 3–4, 117
in waste collection 4, 125–44
see also coalition formation
cost sharing rules 117–23, 165, 168, 173
as monotonic 174
costs
of abatement 37, 39, 43, 45, 47–52
composition of 164–5
liability 145–6
process-based 46–7
transaction 65, 221
of waste collection 131–2, 136, 139, 143
Cournot oligopoly game 75, 187–8, 208, 232
Cournot-Walras equilibrium 217–20
Data Envelopment Analysis ((DEA) 4, 165, 166, 174–83
weaknesses in 182, 183
De Zeeuw, A. 65–6, 88, 108
decision making 61
coalition formation and 9, 224–45
in domestic policy 15–17
game theory and 126–44, 224–45
see also voting behaviour
decision trees 87–8, 90, 91–2, 94
defection see unilateral defection problem
degenerative risk 147
delta games 225
delta rule, of coalition formation 35, 246
Denmark, emission impact indices for 176–83
Deprez, O. 147
deviator's curse 240
see also unilateral defection problem
DICE (Dynamic Integrated model of the Climate and the Economy) model 93–4
differential games 88–9
definition 108
domestic policy
decision making in 15–17
on environmental standards 9–10
international economy and 11–15
political equilibrium in 16–17
Driessen, T. 113
duality theory 214–15
dynamic consistency 91
dynamic games 91, 189, 195–200, 108
replicator dynamics 200–201

ecological transfer functions 12
economics see international economy
egalitarian equity principle 47, 48
emission control/reduction 37, 38, 41, 87
cost of 37, 39, 43, 45, 47–52
equity in 2, 39, 46–61
game theory and 187–246
incentives for 37–9, 40–45, 54, 56, 57–8, 224
Kyoto flexibility mechanisms for 38
Kyoto Protocol see Kyoto Protocol
profitability issues 38, 39–40, 46–52, 90–91, 92–106, 107, 225
emission impact indices, of Danish data 176–83
emission trading 2, 38–9, 43, 52, 62
clearing mechanism for 5
as competitive 212–23
game theory and 212–23

transferable-utility production games 5, 213, 219–20
licences, demand for 213, 214–18, 222
licences, pricing of 212–13, 214–16, 222
by oligopolies 5, 212–23
environmental costs see cost sharing methods
environmental impact of consumption activities 4, 87, 164–84
definition 164, 173
emission indices 176–83
measurement of 166, 172–4
environmental insurance
co-insurance games 146, 150–53
companies dealing in 146, 159–60
cost sharing in 4, 145–63
game theory and 146–63
risks in 4, 145
environmental issues 145, 180
acid rain 108
climate change 37, 41, 87
consumption activities and 164, 166
Global Warming Potential (GWP) 180–82
greenhouse gases 212–23
liability costs 145–6
pollution 145–6
transfrontier 9–36
environmental management
emission control see emission control/reduction
game theory and 187–246
resource exploitation 187–211
waste collection 4, 125–44
environmental risk 145
equilibria
boundary/inner 190, 200–207
conjectural cooperative (CCE) 5, 226–39
in cooperative games 79–83, 224–45
corner 202–3
Cournot-Walras 217–20
in evolutionary games 190, 200–207
International Non-cooperative Political Equilibrium (INPE)
concept 10, 17–27, 29, 31–2, 33
in issue linkage 79–83
Nash see Nash equilibria
partial agreements equilibrium (PAE) 22–3, 31, 33
see also political equilibrium; stability
equilibrium agreements see equity issues
equity issues
in abatement costs 39, 48–52
allocation-based 46–7, 48
in emission control/reduction 2, 39, 46–61
outcome-based 46–7, 49–50
process-based 46–7, 49
types of 46–8
European Commission 125, 142–3
European union, waste collection legislation 43, 44, 53–7
evolutionary games
dynamic 189, 195–200, 208
equilibria in 190, 200–207
Nash equilibria 189, 193, 195, 196, 208
reaction functions 192–3
in resource exploitation 5, 187–211
two-dimensional 200–207
unilateral defection problem in 187, 188–9
Evestigneve, I.V. 221
Eyckmans, J. 52, 62
feedback games 3, 87, 88–110
dynamically consistent equilibrium in 88
information structure 90–91
results from 92–106
fishing see commercial fisheries
Flam, S.D. 221
Folmer, H. et al. 65–6
Fragnelli, V. 137, 148–9, 152
free-riding incentives 2, 3, 37, 38, 42, 43, 44, 53, 65
issue linkage and 66, 67, 70–71, 76, 83–4
offsetting of 39–40, 66
Friedman, E. 165, 172, 173, 174
gamma games 225
Gerber, H.U. 147
Gilotte, L. 52
Global Warming Potential (GWP) 180–82
Gordon, H.S. 187
greenhouse gases 212–13
emission trading and 212–13
growth equations 189–90, 195–200
Hahn, R.W. 221
Haller, H. 35
Hart, S. 10, 21, 35, 225, 246
Heal, G. 62
Hirokawa, M. 29, 31
Holden, S. 35
horizontal equity principle 48
Hourcade, J.C. 52
impact indices see emission impact indices
impact studies see environmental impact
incentives 2, 10
for emission control/reduction 37–9, 40–45, 54, 56, 57–8, 59–60
for free riding 2, 3, 37, 38, 39–40, 42, 43, 44, 53, 65, 66, 70–71
for international agreements 2, 10, 37–9, 40–45, 54, 56, 57–8, 59–60
income levels 12–13
insurance see environmental insurance
insurance companies 145, 159–60
integrated assessment models (IAM) 89–94, 98
international agreements
game theory and 10, 17–27
incentives for 2, 10, 37–9, 40–45, 54, 56, 57–8, 59–60
Kyoto Protocol see Kyoto Protocol negotiations on see negotiation process
self-enforcing 38
stability of see stability
on transfrontier pollution 9–36
see also climate policy; coalition formation
international economy 42, 93
domestic policy and 11–15
externalities in 166–8
structure of 11–12, 166–8
International Non-cooperative Political Equilibrium (INPE) concept  10, 17–27, 29, 31–2, 33
inverse optimisation  42
IPCC (International Panel on Climate Change) 61
Summary for Policymakers 38
irrigation projects 113
issue linkage  2–3
definition  65
effectiveness of 66
equilibrium in 79–83
free-riding and 66, 67, 70–71, 76, 83–4
game theory and 67–85
in negotiation process 65–86
profitability in 72–9
transaction costs in 65
Italy, waste collection in 126–43
Jacobian matrices 203
Japan 43, 44, 45, 53–7
joint projects
cost sharing methods 3–4, 113–24
game theory and 114–24
structure of 114, 118
see also coalition formation; Kyoto Protocol
Kakutani fixed point theorem 29, 31
Kaneko, M. 26
Kantian allocation rule 47, 49
Katsoulacos, Y. 66
Kopel, 187, 188
Kurz, M. 10, 21, 35, 225, 246
Kyoto forever hypothesis 41–5, 50, 51, 61, 87, 88, 98, 102
Kyoto Protocol 2, 3, 87
Annex I countries 41-2, 43, 45, 61
Annex B countries 87, 93–4
emission trading under 221
flexibility mechanisms 38
future of 87–110
incentives to sign 40–45
profitability of 40–45
ratification of 38
US non-ratification 61, 222
as self-enforcing 38, 42
stability of 38–9, 40–45, 61
Lagrange multipliers 214–15
Lari, E. 150
Lemaire, J. 146–7
Levhari, D. 187
liability issues 145–6
see also environmental insurance
linear aggregation 174
linkages see issue linkages
Mäler, K.-G. 108
Marchiori, C. 62, 85
Marina, M.E. 148–9, 150
marine pollution 145
market justice criteria 49
market price 189
Mesterton-Gibbons, M. 187
Mirman, L.J. 187
Mohr, E. 66
Montgomery, D.W. 212
Morgenstern, O. 225
Moulin, H. 165, 169, 172, 173, 174
multistage sequential games 90, 91
Nakayama, M. 35
Nash bargaining rule 59
Nash equilibria 40, 45, 68, 69
in coalition games 225, 226, 227
in evolutionary games 189, 193, 195, 196, 208
feedback 88–110
open-loop 87, 88–9, 94–106
in production games 216–17
strict 35
strong 10–11, 19, 23–6, 35, 225, 226, 227, 228–9, 246
in strategic form games 225, 226, 227, 228–9, 231, 232, 235, 236, 240, 241
Nash policy game 68
Nash stability requirement 225
natural resources see resource exploitation
negotiation process
coalition formation see coalition formation
equity in 39, 46–61
future of 87–110
game theory and 2, 9–36, 89–92
issue linkage in 65–86
stability in 38, 39–40, 46–52

Index
Index

strategic issues in 65–86
noise pollution 145
non-cooperative games 38, 65
International Non-cooperative Political Equilibrium (INPE) concept 10, 17–27, 29, 31–2, 33
two stage 67–85
unilateral defection 187, 188–9, 190–93, 200–207, 208–9, 224–45
non-cooperative political equilibrium 17–27
non-smooth analysis 222
Norway 222
Okuguchi, K. 187–8, 202, 208
oligopolies
competitive 212–23
Cournot oligopoly game 75, 187–8, 208
emission trading by 5, 212–23
non-cooperation between 188
Olsder, G.J. 90, 108
one-dimensional cost allocation 138–42
one-point solutions 4, 138–9
Shapley values 115, 139–42, 143
open-loop games 3, 87, 88–110
definition 91
as inconsistent 106
information structure 90–91
results from 92–106
optimisation, inverse 42
outcome-based costs 46–7
partial agreements equilibrium (PAE) 22–3, 31, 33
payoffs see profitability issues
Petit, M.L.
Control Theory and Dynamic Games 108
political equilibrium
domestic 16–17
international 17–18
non-cooperative 17–27
polluter pays principle 47
pollution
depopulation 145
liability costs 145–6
transfrontier 9–36
see also environmental issues
pollution control see emission control/reduction
price levels see market price
prisoner’s dilemma problem 187, 189, 246
process-based costs 46–7
production games 212–13, 214–20
Cournot-Walras equilibrium 217–20
demand curves 213, 214–18
Nash equilibria in 216–17
production technology 12, 165, 167, 176
Total Factor Productivity (TFP) 93
productivity analysis 176, 177, 180
Cobb Douglas production function 41, 191, 240
profit maximization 187–8, 189, 190–95
profitability issues 22–3, 59–60
definition 39
in emission control/reduction 38, 39–40, 46–52, 90–91, 92–106, 107, 225
in issue linkage 72–9
Kyoto Protocol and 40–45
strong 39, 43, 44–5, 48, 50, 51, 52, 56
weak 39, 43, 44–5, 50, 51, 54–5, 57
public good game 232
quota exchange see emission trading
railway networks 113
Ramsey growth model 93
random order methods 165, 173–4
ratification constraints, in international agreements 9–36
ratification voting game 19–21
Rawls’s criteria 47, 49
renewable resources 208–9
resource exploitation 4–5
commercial fisheries 187–8
cooperation in 188, 189, 190–93, 200–207, 208–9
evolutionary game approach 5, 187–211
growth equations in 189–90, 195–200
renewable resources 208–9
Topkis, D.M.  
*Supermodularity and Complementarities* 226, 230, 231

Total factor Productivity (TFP) 93

trade liberalisation 66

trade-offs 3

tragedy of the commons problem 187

transaction costs 65, 221

transfer schemes see emission trading

transferable-utility production games 5, 213, 219–20

transfrontier pollution, international agreements on 9–36, 37

transfrontier pollution, international agreements on 9–36, 37

travel agencies 137

TU game 153–4, 157

Tulkens, H. 10, 17, 23, 26, 27, 31, 35, 43, 52, 62, 225, 246

UN Framework Convention on Climate Change 46

unanimity voting 84

unilateral defection problem in cooperative games 187, 188–9, 190–93, 200–207, 208–9
deviator’s curse 240

in strategic form games 224–45

United States 43, 44, 53–4, 56–7
emission trading in 221

Kyoto Protocol, non-ratification of 61, 222

Valverde, J. et al. 108

van den Nouweland, A. 33

van der Ploeg, F. 88, 108

Varian’s no-envy criterion 47

vector cost allocation 4, 164–5, 168–74, 177

as restrictive 183

vertical equity principle 48

Visual Basic 6.0 programming language 126, 132–3

von Neumann, J. 225

voting behaviour 10

game theory and 2, 15–17, 19–21, 67, 84

preferences 27

unanimity voting 84

see also decision making

waste collection 125–6

container numbers needed 127–9
cost of 131–2, 136, 139, 143
cost sharing in 4, 125–44
curb side 126–8

EU legislation on 4, 125, 142–3
game theory and 126–44

quantitative evaluation of 4, 126–32
time needed for completion 130, 135, 136

vehicle numbers needed 128, 129–30, 131

water pollution 145

welfare distribution 89, 218–20

abatement costs and 47, 48

Weyant, J. 52

Willett, T.D. 65

Wooders, M. 33

Yang, Z. 52, 62

Yi, S.-S. 35, 62, 246

Young, H.P. 113

Zaim, O. 165

zero-sum games 225