

Index

- Abler, D. 242, 246, 294
Acemoglu, D. 163
Africa, technology spillovers and FDI
 410–15
 competition for market share 410,
 412–13, 414
 data and methodology 411–13
 research results 413–15
 see also individual countries
Agras, J. 5, 9, 241, 261
agriculture
 cobweb model and structural change
 in, Japan 401–402
 export share, factors affecting, US
 310
 productivity, R&D and interstate
 spillover, US 300
 returns to scale, US 311–12
 subsidies, Japan 401
 see also pesticides
Ahearn, M. 300, 304
Aitken, B. 410, 412
Akao, K. 219, 274, 417
Aldy, J. 119
Alpay, E. 277–8
Anderson, D. 241
Anderson, J. 192, 193, 194, 196
Andreoni, J. 241–2, 244, 245, 260, 261
Ansuategi, A. 241
Antoniou, A. 404
Antweiler, W. 13, 21, 46, 53, 55–6, 57,
 59, 65, 66, 69, 180, 241, 292–8,
 308–309, 312, 314
Arellano, M. 58, 63, 128, 330
Argentina 184, 187
Arrow, K. 5, 27, 49, 256
Atkinson, S. 95, 126
Auffhammer, M. 26
Australia
 CO₂ emissions–income relationship
 33, 37
 coal share in primary energy 35, 37
 energy price-induced technological
 change and catch-up effect 146
 environmental efficiency 104–105
 environmental productivity 109
 trade-induced technological change
 185, 189
Austria 35, 185, 189
Azomahou, T. 4, 6, 8, 21, 26, 27, 28,
 29, 36, 47, 53, 96, 121
Bacsi, Z. 404
Bala, V. 404
Balasubramanyam, V. 340
Balk, B. 280
Ball, E. 120
Ball, V. 247, 262, 283, 304, 314
Bangladesh 184, 187
Banker, R. 275
Barbera, A. 277
Barbier, E. 28
Barnett, W. 404
Barro, E. 64
Basberg, B. 134
Baumol, W. 292
Bautista, R. 411–12
Belaire-Franch, J. 404
Belgium 31, 35, 185, 189
Bella, A. 219, 220
Bergstrand, J. 192, 193, 194, 196, 197
Berman, E. 277
Beron, K. 59, 84
Bertinelli, L. 6, 7, 8, 27–8
Bhagwati, J. 205
Binswanger, H. 158
biochemical oxygen demand (BOD)
 pollution emissions 46, 47, 48, 49, 52
 and trade openness and
 environmental quality 56–9,
 63–6, 67–76, 81, 86–8, 92
Blomström, M. 410

- Blundell, R. 330, 413
 Boisso, D. 197
 Bolivia 184, 187
 Bond, S. 58, 63, 128, 330, 413
 Bovenberg A. 274–5, 288
 Bowen, H. 313
 Boyce, J. 5, 7
 Boyd, G. 126
 Braden, J. 93
 Bradford, R. 275, 288
 Brazil 147
 Brock, W. 3, 20, 28
 Brunnermeier, S. 355–6
 Bui, L. 277
 Bulte, E. 241
 Burbidge, J. 144
 Burfisher, M. 205, 206
 Burton, M. 404
 Burtraw, D. 219, 220, 234, 235
 Bwalya, S. 411, 412
- Cameroon 104–105, 107, 184, 187
 Canada
 CO₂ emissions–income relationship
 34, 37
 coal share in primary energy 35, 37
 dairy product tariffs 204
 environmental efficiency 104–105
 environmental productivity 109
 NAFTA tariff preferences 193,
 204
 trade-induced technological change
 185, 189
- capital
 capital–labor effect, trade openness
 and environmental quality 55,
 59–60, 61, 64, 65, 74–5, 88
 and pollution intensity, relationship
 between, US 297–8, 308–309
 and trade-induced technological
 change 166, 169–70, 171–2,
 178–9
 see also GDP; income
- Caputo, M. 135
 Carlson, C. 220, 225, 226, 234, 235
 Carroll, W. 340
 Carson, R. 26
 Cavendish, W. 241
 Caves, D. 301
 Cavlovic, T. 241
- Celikkol, P. 135
 Chambers, R. 276, 280
 Chapman, D. 5, 9, 241, 261
 Charnes, A. 242, 251, 277
 Chatrath, A. 391
 Chaudhri, E. 179
 Chavas, J. 304, 392, 402, 404
 Chen, H. 321, 322, 323, 324
 Chen, M. 342, 356, 360, 363
 Chen, Q. 322, 324
 Chen, X. 323, 324
 Cheremisinoff, N. 18, 73
 Chib, S. 360, 363
 Chile 104–105, 107, 184, 187
 Chimeli, A. 93
 China, environmental policy
 implementation and effectiveness
 318–54
 administrative measures for
 environmental law
 implementation 322–4
 citizens' complaint model 326,
 327–8, 336–7
 complaint–policy model 328,
 336–7
 economic development and regional
 ordering 344–6
 economic incentives, apparent
 ineffectiveness of 347–8
 EKC model 325–6, 333–4, 338–9
 emissions permit system 323, 328,
 330, 336, 341, 345
 environmental impact assessment
 system (EIA) 320, 322, 328–30,
 336–8, 340, 342, 345
 Environmental Petition method 335,
 338, 342–3
 environmental policies and
 enforcement model 326
 income–complaint model 327–8,
 334–5
 income–pollution relationship 343
 industrialization and urbanization
 340
 investment–pollution model
 estimation 343
 legal system and organizations
 320–21
 policy–pollution model 329, 337–44,
 345, 354

- pollution abatement for
 noncompliance by a designated
 date (PAND) 320, 322–4,
 328–30, 336, 338, 339, 342, 343,
 345–7
 pollution discharge reporting 323
 pollution levy system 322, 323, 328,
 329, 330, 338, 341, 342, 345,
 346–7
 regional policy–pollution model
 estimation 345
 research background 324–5
 research data 330–33
 research methodology 329–30
 research model 325–30
 research results 333–45
 scale effect 324, 337
 shutting down, merging and
 transferring (ST), enforcement
 of 320, 322, 324, 328–31, 336,
 338, 340, 342–3, 345–7
 statistical data, reliability of 332–3
 structure effect 324, 337, 338, 341–2,
 345
 surface-water pollution and
 environmental protection
 318–19
 technique effect 324, 337–8
 the three simultaneity system (TTS)
 320, 322, 328, 329, 330, 338,
 340–41, 342, 345–6
 total emissions control system 323
 transmission model 326–7
 water pollution control policies
 320–24
 water pollution control policies,
 problems with 324
 Chintrakarn, P. 78
 Chung, Y. 95, 98, 251, 271, 301, 302,
 303
 citizens' complaint model, China 326,
 327–8, 336–7
 clean development mechanism (CDM)
 projects, India 409–10
 clean technological inventions *see*
 Japan, clean technological
 inventions in
 CO₂ emissions
 EKC previous studies applied to 8,
 9, 10
 energy price-induced technological
 change 142–3, 146, 152
 and energy substitution *see* energy
 substitution and carbon dioxide
 emissions
 and environmental productivity
 103–17
 and pollution, natural resources and
 economic growth 47–9, 50, 51–2
 and trade openness and
 environmental quality 56, 57,
 58, 59, 63, 64, 65, 66, 67–76, 81,
 86–8, 92
 trade-induced technological change
 171–2, 173, 175–9
 see also emissions; NO₂ emissions;
 SO₂ emissions
 coal
 clean coal technology, Japan 367,
 368, 369, 371, 373, 374
 intensity and income, relationship
 between 43
 share in OECD countries, effect of
 36–9
 share in primary energy 35
 cobweb model and structural change in
 agricultural industry, Japan
 401–402
 Cochrane, W. 391
 Coe, D. 179, 300
 Coelli, T. 140
 Cohen, M. 325, 355–6
 Cole, M. 5, 10, 18, 20, 21, 44, 52, 55–9,
 62–6, 69, 73, 77–9, 180, 256, 314
 Colombia 104–105, 107, 184, 187
 Common, M. 5, 7, 28
 competitiveness, policy-induced *see*
 US, policy-induced
 competitiveness
 composition effect
 and environmental Kuznets curve
 (EKC) 14–18
 trade liberalization, technology and
 the environment, US 295, 297
 trade openness and environmental
 quality 55, 56, 57, 60–61, 62, 69,
 75, 76
 Considine, T. 220, 235
 Conway, G. 288
 Coondoo, D. 28

- Copeland, B. 3, 4, 26, 55, 57, 77, 163, 243, 261, 292, 294, 295, 313, 314, 324
- Costa Rica 104–105, 107, 184, 187
- Côte d'Ivoire 104–105, 107, 184, 187
- Cox, T. 304
- Cropper, M. 120
- Cui, J. 322, 324
- Cyprus 185, 189
- Czech Republic 35
- Dacosta, M. 340
- Dasgupta, S. 3, 4, 6, 19, 21, 101, 241, 334–5, 336
- De Bruyn, S. 262
- De Clercq, M. 120
- De Groot, H. 333
- De Zeeuw, A. 275, 288
- Deacon, R. 28, 120
- Deardorff, A. 192–3
- Debreu, G. 280
- Denmark 31, 35, 104–105, 109, 185, 189
- Diewert, W. 138, 167
- Dijkgraaf, E. 49–50, 121
- Dinda, S. 5, 28, 93
- distance function approach
- emissions trading, US 221–2, 223–4, 227, 232–3
 - energy price-induced technological change 135–6, 140–45
 - environmental productivity 95–6, 98, 99, 103, 126–7
 - trade liberalization, technology and the environment, US 302–303
 - trade-induced technological change 164–5, 166–73
- Dollar, D. 81
- Dominican Republic 104–105, 107, 184, 187
- Dorfman, R. 95, 126
- Dowrick, S. 120
- Ebert, U. 121
- Echevarria, C. 14
- Eckmann, J.-P. 392, 397
- economic growth *see* pollution, natural resources and economic growth
- economic integration, regional *see* regional economic integration
- economic policy intervention *see* Japan, economic policy intervention, non-linear effects
- Ecuador 104–105, 107, 184, 187
- Ederington, J. 78, 294
- Edgerton, M. 120
- efficiency change
- efficiency measures and catch-up effect, US 301, 302, 305–307
 - and energy price-induced technological change 136, 137, 139, 146, 147–8, 151
 - see also* inefficiency levels and presence of catch-up effect
- Egypt 104–105, 107, 184, 187
- EKC *see* environmental Kuznets curve (EKC)
- Ekins, P. 241
- El Salvador 104–105, 108, 185
- Elliot, R. 10, 18, 20, 21, 55–9, 62–5, 66, 69, 73, 77–9, 180, 314
- Elsner, J. 391
- emissions
- and global-warming gases, India 407
 - permit system, China 323, 328, 330, 336, 341, 345
 - prices, long-term, US 225–6, 228
 - standards, Japan 367
 - total emissions control system, China 323
 - see also* CO₂ emissions; NO₂ emissions; pollution; SO₂ emissions
- energy
- consumption per capita, and trade openness and environmental quality 57, 67–71, 88
 - R&D expenditures, Japan 364, 365, 366–7, 373
 - sector finance, India 409–10
 - technology patents, Japan 365–6, 374–9
 - and trade-induced technological change 166, 178–9
 - use, EKC previous studies applied to 9, 10
 - energy price-induced technological change 133–62
 - capital-biased 142–3, 153, 156

- CO₂ 142–3, 146, 152
- distance function approach 135–6, 140–45
- and efficiency change (EFFCH) 136, 137, 139, 146, 147–8, 151
- energy consumption and oil price volatility 141–4, 148–51, 154–5
- energy research 147–50
- energy-biased 142–3, 153, 156
- exogenous technological change (ETCH) 134, 136–7, 138, 139, 145, 146–54, 155, 156, 157
- and GDP 142–3, 146, 151–5
- and induced technological change (ITCH) 134–9, 144, 146, 147, 148–9, 151, 155–6
- inefficiency levels and presence of catch-up effect 146
- input bias direction 155–6
- labor-biased 142–3, 153, 156
- and long-run energy prices 144, 145, 147
- Malmquist–Luenberger productivity indicators 136–9
- output bias direction 151–5
- and productivity change (PCH) 136, 138–9, 146
- research data 141–4
- research estimation 140–41
- research results 144–56
- SO₂ 137, 142–3, 146, 152
- theoretical framework 135–9
- energy substitution and carbon dioxide emissions 26–43
- coal intensity and income, relationship between 43
- coal share in OECD countries, effect of 36–9
- coal share in primary energy 35
- country-level estimation results 28–36
- descriptive statistics 30
- International Energy Agency (IEA) forecast 26
- literature review 27–8
- environmental damage model, US 295–9, 305–307, 308–10
- environmental degradation and risk patterns, US 247–8, 250
- environmental impact assessment system (EIA), China 320, 322, 328–30, 336–8, 340, 342, 345
- environmental Kuznets curve (EKC)
- background 3–4
- and composition effect 14–18
- decomposition of, and income variable 13–19
- energy substitution and carbon dioxide emissions *see* energy substitution and carbon dioxide emissions
- environmental policy implementation and effectiveness, China 325–6, 333–4, 338–9
- environmental productivity *see* environmental productivity
- estimation results 11–19
- and income effects 244
- and increasing returns to abating pollution 244–5, 254
- literature review 5–6, 7, 8, 9
- methodology and data 6–11
- multivariable semiparametric analysis 7–10
- and policy-induced competitiveness, US 276, 282, 286
- pollution abatement, increasing returns to *see* US, increasing returns to pollution abatement
- pollution, natural resources and economic growth *see* pollution, natural resources and economic growth
- previous studies applied to CO₂ 8, 9, 10
- previous studies applied to energy use 9, 10
- previous studies applied to SO₂ 7, 9, 10
- relationship between environmental quality and GDP per capita 11–13
- and scale effect 14, 15–17
- sensitivity of results, concerns over 5–6
- and technique effects 10, 18–19
- and threshold effects 244, 245

- and trade liberalization, technology and the environment, US 294
- and trade openness and environmental quality 92
- environmental policy
 - implementation and effectiveness, China *see* China, environmental policy implementation and effectiveness
 - and R&D, and US trade liberalization 295, 298, 310
- environmental productivity 93–132
 - CO₂ emissions 103–17
 - descriptive statistics 103
 - determinants of 132
 - and distance function approach 95–6, 98, 99, 103, 126–7
 - EKC-type relationship 101–102, 111–17
 - empirical strategy 94–6
 - environmental efficiency 95, 96
 - environmental efficiency, determinants of 129–30
 - environmental efficiency, and income 111–15
 - environmental efficiency, and productivity measurement and results 97–101, 103–11
 - and income effect 118–19
 - and Malmquist–Luenberger (ML) index 99–100
 - and pollution abatement technologies 93–4, 95
 - and regulation, US 277–8, 287–8
 - research data and results 102–17
 - research model 97–102
 - robustness check 128–32
 - SO₂ emissions 103–17
 - and technological change 96, 99, 101, 116–17, 131
 - and total factor productivity (TFP) 93, 95, 107–108, 110, 111
 - US, and increasing returns to pollution abatement 271–3
- environmental quality, and trade openness *see* trade openness and environmental quality
- Esty, D. 4, 19, 241, 325
- Ethiopia 104–105, 107, 184, 187
- EU 193, 197, 198, 199, 200–204
 - see also* individual countries
- exogenous technological change (ETC)
 - and trade-induced technological change 166, 167–8, 170, 173, 175, 177–9
 - US, emissions trading 221, 228, 229, 230–33
- export share model, US 299–300, 305–307, 309, 310–12
- Ezekiel, M. 392, 401
- Fairman, D. 106
- Färe, R. 94, 95, 97, 98, 121, 126–7, 136, 137, 139, 158, 165, 170, 180, 222, 226, 235, 251, 275, 277, 293, 301, 302
- Farrell, M. 280
- Fernandez-Carnejo, J. 245
- Ferrantino, M. 197
- Finland 35, 185, 189
- Forrester, J. 313
- Foster, V. 246
- France 31, 35, 37, 174, 185, 189
- Frankel, J. 21, 46, 47, 55, 57, 59, 60, 78, 81, 82, 170, 180, 193, 292, 294
- free trade, environmental effects of, US 308–10
 - see also* trade openness and environmental quality
- Fu, T. 246
- Fu, X. 340
- Fujita, M. 300
- Fukao, K. 193, 387, 388
- Gabon 104–105, 107, 184, 187
- Galeotti, M. 5, 8
- Gallagher, K. 134, 144, 147, 151
- Galor, O. 300
- Gardner, B. 391
- Garg, A. 407, 408
- GDP
 - and energy price-induced technological change 142–3, 146, 151–5
 - per capita, and environmental quality, relationship between 11–13

- and trade openness and
environmental quality 56, 64,
65, 67–71, 76, 87
- and trade-induced technological
change 166, 171–2
see also capital; income
- Gelfand, A. 383
- geothermal power, Japan 365, 367, 368,
369, 371, 373
- Germany 31, 35
- Geweke, J. 356, 360
- Ghana 104–105, 107, 184, 187
- Gilmore, C. 404
- Gollop, F. 95
- Golombek, R. 163
- Goodwin, R. 391
- Gopinath, M. 299
- Gorg, H. 411
- Gould, D. 193
- Granger causality test, and policy-
induced competitiveness, US 276,
281–3, 286
- Grassberger, P. 391, 392
- Greece 35, 104–105, 109, 185, 189
- Greene, W. 141, 169
- Grosskopf, S. 121
- Grossman, G. 3, 5, 7, 20, 26, 44, 77, 93,
120, 163, 241, 294, 295, 326
- Grubler, A. 29, 40
- Guatemala 104–105, 107, 184, 187
- Gupta, S. 410
- Haddad, M. 411, 412
- Hailu, A. 121, 126, 158, 235
- Haiti 184, 187
- Hakura, D. 179
- Halkos, G. 5, 7
- Hall, M. 275
- Hall, R. 158, 181
- Hansen, L. 249, 304
- Hanson, K. 314
- Harbaugh, W. 26, 27, 28, 44–5, 55,
241
- Harper, C. 245
- Harrigan, J. 293–4, 299, 312, 313
- Harrison, A. 144, 410, 411, 412
- Hastie, T. 8, 121
- Havrylyshyn, O. 180
- Hayami, Y. 133, 156, 158
- Hayward, S. 276
- heat pump (HP) power, Japan 365, 367,
368, 369, 371, 375
- Heckscher, E. 293
- Hegger, R. 392, 397
- Helpman, E. 163, 300
- Heston, A. 102
- Hettige, H. 64
- Hicks, J. 133
- Hilton, H. 28, 241, 261
- Hoel, M. 163
- Holt, M. 392, 402, 404
- Holtz-Eakin, D. 5, 8, 27, 120
- Honduras 104–105, 107, 184, 187
- Hong Kong 185, 189
- Hufbauer, G. 191
- Hungary 31, 35, 184, 187
- hydrogen power, Japan 365, 366–7,
368, 369
- Iceland 35, 104–105, 109, 185, 189
- Im, K. 254, 257, 304
- income
effect, and environmental
productivity 118–19
effect, and pollution, natural
resources and economic growth
47–8, 49
equation, trade openness and
environmental quality 60, 61–2,
81
income–complaint model, China
327–8, 334–5
income–pollution relationship,
China 343
variable, and environmental Kuznets
curve (EKC) decomposition
13–19
see also capital; GDP
- India
clean development mechanism
(CDM) projects 409–10
climate change mitigation 407–409
climate-resilient economy 406–10
economic growth 406–10
efficiency change (EFFCH) 147–8
emissions and global-warming gases
407
energy research 147–50
energy sector finance 409–10
environmental efficiency 104–105

- environmental productivity 107
- exogenous technological change 147, 151, 155
- and induced technological change (ITCH) 148–9, 151, 155
- industry sector, energy consumption 408
- input-biased technological change 155–6
- National Action Plan on Climate Change (NAPCC) 408
- output-biased technological change 154, 155
- power sector, demand problems 408
- renewable energy supplies 408–409
- sustainable development and poverty reduction 407
- total factor productivity 184
- trade-induced technological change 184, 187
- Indonesia 104–105, 107, 184, 187
- induced technological change 134–9, 144, 146–9, 151, 155–6
 - emissions trading, US 221, 228, 229, 230–33
- inefficiency levels and presence of
 - catch-up effect
 - emissions trading, US 228–9
 - energy price-induced technological change 146
 - trade-induced technological change 173–4
 - see also* efficiency change
- input bias direction
 - energy price-induced technological change 155–6
 - trade-induced technological change 178–9
- international environmental treaties 59, 74, 84–5
- Iran 104–105, 107, 146, 184, 188
- Ireland 35, 185, 189
- Israel 185
- Israel, D. 244
- Italy 33, 35, 146, 185, 189
- Jaffe, A. 93, 95, 134, 156, 158, 220, 235, 274, 275, 277, 285, 288, 313, 355, 382, 383
- Jamaica 104–105, 107, 184, 188
- Japan
 - CO₂ emissions–income relationship 33
 - coal share in primary energy 35
 - efficiency change (EFFCH) 147–8
 - energy research 147–50
 - environmental efficiency 104–105
 - environmental productivity 109
 - exogenous technological change 147, 155
 - and induced technological change (ITCH) 148–9, 151, 155
 - input-biased technological change 155–6
 - output-biased technological change 154, 155
 - trade-induced technological change 185, 189
- Japan, clean technological inventions
 - in 355–90
 - causality tests 368–72, 374–6
 - clean coal technology 367, 368, 369, 371, 373, 374
 - and ecolabeled seafood consumption 382
 - economic growth, historic 387–90
 - emission standards 367
 - energy technology patents 365–6, 374–9
 - environmental regulation stringency 364
 - future research and Jevons Paradox 381
 - and GARCH model 358, 359, 360–61, 368
 - geothermal power 365, 367, 368, 369, 371, 373
 - government energy R&D expenditures 364, 365, 366–7, 373
 - heat pump (HP) power 365, 367, 368, 369, 371, 375
 - hydrogen power 365, 366–7, 368, 369
 - Markov chain Monte Carlo (MCMC) simulation 356, 358–9, 360, 361–3, 368–71, 380, 385–6
 - NO₂ emissions, technology to reduce 357, 358, 364–5, 367, 368–72, 380

- oil crisis and alternative energy
 - sources 358
- and organic milk consumption
 - 381–2
- pollution abatement technology
 - patents 364, 372–3
- and pollution regulation 356–7
- research data 363–7
- research estimation 361–3
- research methodology 360
- research model 360–63
- research results 367–80
- SO₂ emissions, technology to reduce
 - 357–8, 364–5, 367, 368–72, 380
- solar power 365, 367, 368, 369, 371, 374
- stochastic volatility (SV) model 358, 360
- Sunshine Program 366, 373
- technology and policy 357–8
- tidal power 365, 367, 368, 369, 371, 373, 375
- wind power 365, 367, 368, 369, 371, 375
- Japan, economic policy intervention,
 - non-linear effects 391–405
 - agricultural subsidies 401
 - background 391–2
 - bifurcation diagram 401–402, 403
 - chaotic time-series analysis 392–401
 - cobweb model and structural change in agricultural industry 401–402
 - delay coordinate embedding 392–3
 - Lyapunov spectrum analysis 392, 393–7, 399
 - and oil crises 400, 401–402
 - piglet price and population data 394–6
 - piglet-pricing 392
 - recurrence plots 397–401
- Javorcik, S. 412
- Jena, P. 134, 158
- Jevons, W. 381
- Jiang, H. 347
- Jiang, T. 319, 325, 341
- Jin, Y. 319, 341
- Jones, C. 158, 181
- Jones, L. 244–5
- Jordan 104–105, 107, 184, 188
- Jorgenson, D. 274, 277
- Kaldor, N. 392
- Kaneko, S. 113, 277, 318, 321, 333, 343, 348, 349
- Kantz, H. 392, 397
- Karemera, D. 251, 271, 272, 283, 284, 289, 294, 299, 415
- Kaufmann, R. 5, 9
- Kellogg, R. 247, 248, 257, 283, 304
- Kelly, D. 241
- Kemp, R. 288
- Kennedy, P. 299
- Kenya 104–105, 107, 184, 188
 - technology spillovers and FDI 411–15
- Keohane, N. 219
- Khanna, N. 241
- Kim, S. 358
- Klein, J. 225
- Kneese, A. 219, 274, 355
- Kokko, A. 410
- Kolstad, C. 220, 235
- Kopp, G. 111, 120
- Korea 35, 104–105, 109, 111, 185, 189
- Kortelainen, M. 120
- Kraay, A. 81
- Krueger, A. 5, 7, 20, 26, 44, 77, 93, 120, 191, 241, 294, 295, 326
- Kumar, S. 120, 126, 158, 173, 181, 235, 406, 407, 408
- Kuosmanen, T. 121
- labor
 - bias, and energy price-induced technological change 142–3, 153, 156
 - capital–labor effect, trade openness and environmental quality 55, 59–60, 61, 64, 65, 74–5, 88
 - and trade-induced technological change 166, 169–70, 171–2, 178–9
- Lange, I. 220
- Lanjouw, J. 158, 277, 355
- Lansink, A. 144, 158, 180, 235
- Larson, D. 220, 235, 404
- Lee, J. 64
- Lefohn, A. 10, 21, 64
- Levinson, A. 28, 180, 241–2, 244, 245, 260, 261, 294
- Li, B. 322, 324

- Li, X. 346
 Li, Z. 323
 Liang, P. 322, 324
 Lichtenberg, F. 158
 Lieb, C. 241
 Lin, J. 340
 Lindmark, M. 241
 Linnemann, H. 194
 Liu, C. 323, 324, 339
 Lohr, L. 246
 Lopez, R. 28
 Lovell, C. 158, 180
 Lu, B. 341
 Luenberger productivity index
 policy-induced competitiveness, US
 276, 279–80, 281, 283–4, 286
 trade-induced technological change
 165–6
 see also Malmquist–Luenberger
 productivity index
 Luxembourg 31, 35, 186, 190
 Luzzati, T. 6, 9
 Lyapunov spectrum analysis, economic
 policy intervention, Japan 392,
 393–7, 399
- McClelland, J. 126
 McConnell, J. 277
 McKibbin, W. 319, 325, 341
 Majumdar, M. 391
 Malaysia 104–105, 107, 184, 188
 Malmquist productivity index, and
 trade liberalization, US 301, 303
 Malmquist–Luenberger productivity
 index
 emissions trading, US 222
 energy price-induced technological
 change 136–9
 and environmental productivity
 99–100
 and increasing returns to pollution
 abatement, US 271–2
 and trade liberalization, technology
 and the environment, US 301–
 302, 303
 see also Luenberger productivity
 index
 Mani, M. 297
 Manuelli, R. 244–5
 Maria, C. 163, 179
- Markov chain Monte Carlo (MCMC)
 simulation, clean technological
 inventions, Japan 356, 358–9, 360,
 361–3, 368–71, 380, 385–6
 Markusen, J. 192
 Marland, G. 10, 21, 64
 Marquetti, A. 102
 Mátyás, L. 249
 May, R. 391
 Mexico
 coal share in primary energy 35
 dairy product tariffs 204–205
 energy price-induced technological
 change and catch-up effect 146
 energy price-induced technological
 change decline 147
 environmental efficiency 104–105
 environmental productivity 107
 environmental regulation and
 productivity 278
 NAFTA tariff preferences 193,
 204–205
 trade-induced technological change
 184, 188
 Meyer, S. 276
 Millimet, D. 6, 7, 26, 44, 78, 241, 255
 Minier, J. 294
 Mitra, S. 28
 Moav, O. 300
 Mody, A. 158, 277, 355
 Mohr, R. 275, 288
 Moomaw, W. 243
 Moon, F. 391, 392
 Morocco 104–105, 107, 184, 188, 411
 Mourato, S. 246
 Mozambique 184, 188
 Murdoch, J. 59, 84
 Murty, M. 120, 126
 Musolesi, A. 415
- NAFTA 193–4, 197, 198, 199, 200–204
 Nakatsuma, T. 359
 Nepal 104–105, 108, 111, 184, 188
 Netherlands 35, 186, 190
 New Zealand 35
 Newell, G. 134, 158
 Nicaragua 184, 188
 Nickell, S. 412
 Nigeria 104–105, 108, 184, 188
 Nitsch, V. 193

- NO₂ emissions
 and pollution, natural resources and economic growth 48, 49
 technology to reduce, Japan 357, 358, 364–5, 367, 368–72, 380
 and trade openness and environmental quality 56, 57, 89–91
see also CO₂ emissions; emissions; SO₂ emissions
- Noguer, M. 78, 81, 82
 Nordhaus, W. 158
 Norman, C. 28, 120
 Norway 34, 35
- Oates, W. 120, 292
- oil
 crises, economic policy intervention, Japan 400, 401–402
 price volatility, and energy price-induced technological change 141–4, 148–51, 154–5
- Ollinger, M. 245
 Ono, M. 159
 Opschoor, J. 262
 Orea, L. 158, 180
 Orsini, M. 6, 9
- output bias direction
 energy price-induced technological change 151–5
 trade-induced technological change 177–8
- Pakistan 104–105, 108, 184, 188
 Palmer, K. 274, 275, 277, 285, 355, 382, 383
 Panagariya, A. 205
 Panama 104–105, 108, 184, 188
 Panayotou, T. 5, 6, 7, 13
 Paraguay 104–105, 108, 185, 188
 Paris, Q. 135
 Paul, C. 246, 294, 310, 312, 314
 Perman, R. 63, 254
 Perrings, C. 241
 Peru 185, 188
 Pesaran, M. 391
- pesticides
 and economic growth, US 267
 and environment and pollution abatement, US 245–7
 and fish life risk, US 251, 252, 258–60
 and human health risk, US 245–7, 248–9, 250–51, 258–60
 leaching, and increasing returns to pollution abatement, US 242, 246, 247, 248–9, 251, 252, 257
 leaching, and trade liberalization, US 294, 305–307, 310, 311
see also agriculture
- Pezzey, J. 262
 Philippines 104–105, 108, 185, 188
 Piao, G. 321, 322, 323, 324
 Pittman, R. 95, 120
 Poland 32, 35, 146
- pollution
 intensity and capital, relationship between, US 297–8, 308–309
 levy system, China 322, 323, 328, 329, 330, 338, 341, 342, 345, 346–7
 policy–pollution model, China 329, 337–44, 345, 354
 regulation, Japan 356–7
 regulation, US, and policy-induced competitiveness 276
 standards, US and trade liberalization 295, 297
 water pollution control policies, China 320–24
see also emissions
- pollution abatement
 for noncompliance by a designated date (PAND), China 320, 322–4, 328–30, 336, 338, 339, 342, 343, 345–7
 technologies, and environmental productivity 93–4, 95
 technologies, and trade openness and environmental quality 73
 technology patents, Japan 364, 372–3
 US *see* US, increasing returns to pollution abatement
- pollution, natural resources and economic growth 44–54
 biochemical oxygen demand (BOD) emissions 46, 47, 48, 49, 52
 and CO₂ 47–9, 50, 51–2
 democracy effect 49, 50

- developed country data, limitations of 49–50, 52
- empirical models and data 45–7
- environmental quality and natural resources estimates 48
- forest areas 48, 49
- and income effects 47–8, 49
- and mineral depletion 48, 49
- and NO₂ 48, 49
- pollutants, estimated turning points 44, 47–52
- pollution haven hypothesis 49
- protected areas 48, 49
 - and regional scale 49, 50, 51
 - research results 47–50
 - and scale effect 46, 47
 - and SO₂ 47, 48, 49
 - statistical problems, possible 49
 - and technique effect 46, 47
 - and total suspended particulates (TSP) 45, 48, 49
 - trade-induced composition effect 49, 50
- Popp, D. 134, 144, 158, 219, 356, 371
- Porter, M. 4, 19, 274, 275, 276, 277, 278, 281–2, 285–7, 382
- Portney, P. 274
- Portugal 35, 186, 190
- Potter, S. 391
- Prescott, E. 93
- Prieto, A. 96
- Procaccia, I. 391, 392
- production technology parameters, emissions trading, US 226–8
- productivity
 - change, and energy price-induced technological change 136, 138–9, 146
 - and environmental regulation, US, and policy-induced competitiveness 277–8, 287–8
 - total factor productivity, and environmental productivity 93, 95, 107–108, 110, 111
 - total factor productivity, technological change, and efficiency change, US 301–302
- productivity measurement
 - policy-induced competitiveness, US 275–6, 279–81, 283–5
 - trade liberalization, US 301–303 and trade-induced technological change 164, 165–6, 175
- regional economic integration 191–215
 - commodities with no statistical significant effects 199
 - commodities with statistically significant effects 198
 - and commodity trade flows 192
 - commodity-specific gravity model 194, 196–7
 - gravity model 191–2, 193, 194, 200–204, 208–15
 - import demand functions specification 195–6
 - literature review 192–4 and multilateralism 205 and preferential treatment 205
 - research model 194–7
 - research results 197–205
 - supply model specification 194–5
- Reinhard, S. 120
- renewable energy supplies, India 408–409
- Repetto, R. 277
- Requate, T. 234–5
- Rezek, J. 6, 19
- Ricardo, D. 293
- Richmond, A. 5, 9
- Roberts, M. 95
- Robinson, S. 205, 314
- Rodriguez, F. 82
- Rodrik, D. 82, 180
- Rogers, K. 6, 19
- Romalis, J. 193
- Romania 146, 185, 188
- Romer, D. 60, 78, 81, 274, 275, 300
- Roodman, D. 337
- Rose, A. 21, 46, 47, 55, 57, 59, 78, 82, 170, 180, 292, 294, 314
- Rosenstein, M. 393
- Ross, M. 106
- Rosser, J. 391
- Rotty, R. 21
- Russell, R. 158, 173, 181
- Ruttan, V. 133, 156, 158, 245, 247
- Saeed, K. 313, 314
- Sakai, K. 392, 401, 404

- scale effect
 and environmental Kuznets curve (EKC) 14, 15–17
 environmental policy implementation and effectiveness, China 324, 337
 and pollution, natural resources and economic growth 46, 47
 trade liberalization, US 295, 297, 308, 311–12
 trade openness and environmental quality 55–6, 57, 60–61, 66, 69, 73, 75, 76
- Schlenker, W. 120
 Schmalensee, R. 5, 8, 40, 50
 Schott, J. 191
 Schraven, B. 411
 Schreiber, T. 392, 397, 403
 Schultz, T. 391
 Schultze, C. 219, 274, 355
 Selden, T. 5, 7, 8, 27, 120, 241
 Senegal 104–105, 108, 185, 188
 Sengupta, R. 408
 Shafik, N. 5, 8, 27
 Shephard, R. 158, 165, 222, 302, 303
 Shortle, J. 242, 246, 294
 Shukla, P. 408
 Siegel, D. 312
 Simpson, D. 275, 288
 Singapore 186, 190
 Siscart, M. 78, 81, 82
 Slovakia 34, 35, 189, 190
 Smith, A. 383
 Smulders, S. 163, 179, 275
- SO₂ emissions
 abatement options, US 220
 and Clean Air Act Amendments (1990 CAAA), US 219
 EKC previous studies applied to 7, 9, 10
 energy price-induced technological change 142–3, 146, 152, 157
 and environmental productivity 103–17
 and pollution, natural resources and economic growth 47, 48, 49
 technology to reduce, Japan 357–8, 364–5, 367, 368–72, 380
- and trade openness and environmental quality 56–9, 63–6, 67–76, 81, 86–8, 92
 trade-induced technological change 171–2, 173, 175–9
see also CO₂ emissions; emissions; NO₂ emissions
 solar power, Japan 365, 367, 368, 369, 371, 374
 Soloaga, I. 206
 Song, D. 5, 7, 120, 241
 Song, T. 333
 South Africa 104–105, 108, 111, 185, 189
 Spain 35, 146, 185, 189
 Sri Lanka 104–105, 107, 184, 188
 Stefanou, S. 135
 Sterman, J. 314
 Stern, D. 3, 4, 5, 7, 8, 9, 21, 26, 28, 46, 47, 63, 93, 96, 102, 120, 141, 169, 241, 254, 324
 Stewart, H. 391, 392
 Stokey, N. 244
 Strobl, E. 6, 27–8, 411
 structure effect, environmental policy implementation, China 324, 337, 338, 341–2, 345
 Sugihara, G. 391
 Sun, L. 341
 Suri, V. 5, 9
 Sweden 32, 35, 104–105, 109, 186, 190
 Swinton, J. 234
 Switzerland 32, 35, 104–105, 109, 185, 189
 Syria 104–105, 108, 185, 188
- Takens, F. 391, 392, 393
 Tanzania 104–105, 108, 185, 189
 technology spillovers and FDI 411–15
 Taskin, F. 93, 96
 Taylor, M. 3, 4, 20, 26, 28, 55, 57, 77, 163, 180, 243, 261, 292, 294, 295, 313, 314, 324
 technique effect
 and environmental Kuznets curve (EKC) 10, 18–19
 environmental policy implementation and effectiveness, China 324, 337–8

- and pollution, natural resources and economic growth 46, 47
- trade liberalization, US 295, 298, 308–309
- trade openness and environmental quality 55–6, 57, 63–4, 66, 73
- technological change
 - energy price-induced *see* energy price-induced technological change
 - and environmental regulation, US 282–3, 287–8
 - exogenous *see* exogenous technological change (ETC)
 - induced *see* induced technological change
 - and policy-induced competitiveness, US 278–9
 - trade liberalization, US 300, 305–307, 312
 - trade-induced *see* trade-induced technological change
 - and US, emissions trading 220–21, 228, 229, 233, 240
- technology
 - clean technological inventions *see* Japan, clean technological inventions in
 - energy technology patents, Japan 365–6, 374–9
 - environmental, farmers using, US 284–5
 - index, and increasing returns to pollution abatement, US 253–4, 257–9, 262
 - NO₂ emissions, technology to reduce, Japan 357, 358, 364–5, 367, 368–72, 380
 - production technology parameters, US, emissions trading 226–8
 - SO₂ emissions, technology to reduce, Japan 357–8, 364–5, 367, 368–72, 380
 - technological progress, US 221–2, 232–3
- Thailand 104–105, 108, 146, 185, 188
- Thierfelder, K. 205
- Thirtle, C. 158
- Thomas, M. 411–12
- Thompson, J. 391, 392
- Tibshirani, R. 8, 121
- tidal power, Japan 365, 367, 368, 369, 371, 373, 375
- time trend
 - emissions trading, US 228
 - increasing returns to pollution abatement, US 241, 254, 261
 - trade-induced technological change 166–7, 170–73
- Togo 104–105, 108, 185, 188
- Torras, M. 5, 7
- trade liberalization *see* US, trade liberalization, technology and the environment
- trade openness and environmental quality 55–92
 - and biochemical oxygen demand (BOD) 56–9, 63–6, 67–76, 81, 86–8, 92
 - capital–labor effect (KLE) 55, 59–60, 61, 64, 65, 74–5, 88
 - and CO₂ 56–9, 63–6, 67–76, 81, 86–8, 92
 - composition effect 55, 56, 57, 60–61, 62, 69, 75, 76
 - descriptive statistics 65
 - and EKC hypothesis 92
 - and endogeneity problems 56, 57–8, 82–3
 - and energy consumption per capita 57, 67–71, 88
 - environmental quality equation 58–60
 - environmental regulation effect (ERE) 55, 56, 59, 61, 74–5
 - estimation results 65–76
 - estimation strategy and data 63–5
 - free trade, environmental effects of, US 308–10
 - and GDP 56, 64, 65, 67–71, 76, 87
 - income equation 60, 61–2, 81
 - international environmental treaties 59, 74, 84–5
 - long-term effects 62–3, 72, 75
 - and nitrogen oxides 56, 57, 89–91
 - parameter estimates 66–74
 - and pollution abatement technologies 73
 - research data 64, 73, 86–8
 - research model 57–63

- results differing from previous studies 65–6
- scale effect 55–6, 57, 60–61, 66, 69, 73, 75, 76
- short-term effects 60–62, 72, 75, 76
- and SO₂ 56–9, 63–6, 67–76, 81, 86–8, 92
- technique effect 55–6, 57, 63–4, 66, 73
- trade openness equation 82–3
 - and water pollution data 64, 73
- trade-induced technological change
 - 163–90
 - and capital 166, 169–70, 171–2, 178–9
 - CO₂ 171–2, 173, 175–9
 - and directional output distance function 164–5, 166–73
 - and energy 166, 178–9
 - estimation procedure and data 168–70
 - and exogenous technological change (ETC) 166, 167–8, 170, 173, 175, 177–9
 - and GDP 166, 171–2
 - inefficiency levels and presence of catch-up effect 173–4
 - input bias direction 178–9
 - and labor 166, 169–70, 171–2, 178–9
 - Luenberger measure of TFP change 165–6
 - output bias direction 177–8
 - and productivity measurement frontier 164, 165–6, 175
 - research model 164–8
 - research results 170–79
 - SO₂ 171–2, 173, 175–9
 - technological progress, direction of 175–7
 - time trend 166–7, 170–73
 - trade openness 166–7, 170–73
- Trinidad 104–105, 109, 185, 188
- Tsonis, A. 391
- Tsurumi, T. 19
- Tunisia 185, 188
- Turkey 35
- Turnovsky, M. 220, 235
- Tybout, J. 180
- Uchida, H. 382
- UK
 - CO₂ emissions–income relationship 32
 - coal share in primary energy 35
 - environmental efficiency 104–105
 - environmental productivity 109, 111
 - inefficiency levels and presence of catch-up effect 174
 - trade-induced technological change 185, 189
- Ulph, A. 275, 288
- Unruh, G. 243
- Uruguay 104–105, 108, 185, 189
- US
 - abatement expenditure and environmental inventions 355–6
 - coal share in primary energy 35
 - dairy industry and market unpredictability 392
 - dairy product tariffs 204–205
 - efficiency change (EFFCH) 147–8
 - energy research 147–50
 - environmental efficiency 104–105
 - environmental productivity 109
 - environmental regulatory pressure and inventions 356
 - exogenous technological change 147
 - and induced technological change (ITCH) 148–9, 151
 - input-biased technological change 155–6
 - NAFTA tariff preferences 193, 204–205
 - output-biased technological change 154–5
 - trade-induced technological change 186, 190
- US, emissions trading 219–40
 - allowance price-induced technological progress 232–3
 - Clean Air Act Amendments (1990 CAAA) 219–20
 - directional output distance function 221–2, 223–4, 227, 232–3
 - exogenous technological change (ETC) 221, 228, 229, 230–33
 - induced technological change (ITC) 221, 228, 229, 230–33

- inefficiency levels and presence of catch-up effect 228–9
- long-term emission prices 225–6, 228
- Malmquist–Luenberger Productivity Indicators 222
- production technology parameters 226–8
- productivity change 239
- research data 224–6
- research estimation 223–4
- research results 226–33
- SO₂ abatement options 220
- SO₂ emissions and Clean Air Act Amendments (1990 CAAA) 219
- and technological change 220–21, 228, 229, 233, 240
- technological progress measurement 221–2
- time trend parameter 228
- US, increasing returns to pollution abatement 241–73
 - and data envelopment analysis (DEA) 242, 251–2
 - econometric methods 249–54
 - and EKC 243–5, 254, 268, 269
 - environmental degradation and risk patterns 247–8, 250
 - environmental productivity measurement 271–3
 - estimated turning point of peak 256
 - GLEAMS model 248
 - and Malmquist–Luenberger productivity index 271–2
 - pesticide leaching 242, 246, 247, 248–9, 251, 252, 257
 - pesticides and economic growth 267
 - pesticides and environment 245–7
 - pesticides and human health risk 245–7, 248–9, 250–51, 258–60
 - pesticides and fish life risk 251, 252, 258–60
 - research data 247–9
 - research results 254–60
 - sensitivity analysis 258, 259–60
 - and state-level agencies 246
 - technology differences between states 250–51
 - technology index 253–4, 257–9, 262
 - threshold exceedance units (TEUs) 248, 270
 - and time-trend variables 241, 254, 261
- US, policy-induced competitiveness 274–91
 - and EKC 276, 282, 286
 - empirical results 283–7
 - environmental regulation and productivity 277–8, 287–8
 - environmental regulation and technological change 282–3, 287–8
 - environmental technology, farmers using 284–5
 - and Granger causality test 276, 281–3, 286
 - literature review 276–9
 - Luenberger productivity index 276, 279–80, 281, 283–4, 286
 - patent counts and R&D 277
 - and pollution regulation 276
 - and Porter hypothesis 274, 275, 276, 277, 278, 281–2, 285–7
 - productivity measurements 275–6, 279–81, 283–5
 - regulations and productivities, causality between 281–3
 - research model 279–83
 - and technological and efficiency changes 278–9
- US, trade liberalization, technology and the environment 292–317
 - agricultural export share, factors affecting 310
 - agricultural productivity, R&D and interstate spillover in 300
 - agriculture, returns to scale in 311–12
 - capital and pollution intensity, relationship between 297–8, 308–309
 - and comparative advantage 293–4
 - composition effect 295, 297
 - distance function approach 302–303
 - efficiency measures and catch-up effect 301, 302, 305–307
 - and EKC 294
 - environmental damage model 295–9, 305–307, 308–10
 - environmental regulations and R&D 295, 298, 310–11

- export share model 299–300,
 305–307, 309, 310–12
 and fish health risk 305–307, 310,
 311
 free trade, environmental effects of
 308–10
 and human health risk 305–307, 308,
 310, 311
 and Malmquist productivity index
 301, 303
 and Malmquist–Luenberger
 productivity index 301–302, 303
 pesticide leaching and runoff 294,
 305–307, 310, 311
 pollution abatement 308
 pollution demand functions 297–8
 and pollution standards 295, 297
 productivity measurement 301–303
 research data 304–307
 research methods 295–303
 research results 308–12
 scale effect 295, 297, 308, 311–12
 technique effect 295, 298, 308–10
 technological and efficiency change
 models 300, 305–307, 312
 total factor productivity,
 technological change, and
 efficiency change 301–302
 and trade barrier reduction 294
 and trade intensity 298–9
- Van, P. 26, 28
 Van der Linde, C. 274, 275, 281, 382
 Van Soest, D. 234, 241
 Van Wincoop, E. 193, 194, 196
 Veeman, T. 121, 126, 158, 235
 Venezuela 104–105, 108, 111, 185, 189
 Verbeke, T. 120
 Vollebergh, H. 49–50
 Vorlow, C. 404
- Wall, H. 206
 Wang, F. 346
- Wang, H. 319, 325, 333, 336, 341,
 342
 Wang, J. 347
 Weisbuch, G. 313
 Welsch, H. 121
 Wheeler, D. 297, 319, 325, 333, 335,
 336, 341
 Widawsky, D. 246
 Wilcoxon, P. 274, 277
 wind power, Japan 365, 367, 368, 369,
 371, 375
 Windmeijer, F. 330
 Winsten, C. 275
 Winston, A. 325
 Winters, L. 206
 Wobst, P. 411
 Wolf, A. 391, 393
 Wood, S. 20
 Wossink, G. 121
- Xepapadeas, A. 275, 288
 Xia, G. 324, 341
 Xiang, Z. 324
- Yaisawarng, S. 225
 Yandle, B. 44, 47, 241
 Yatchew, A. 101–2
 Yoruk, B. 95
 Yu, H. 322, 324
 Yue, X. 387, 388
- Zaim, O. 93, 95, 96
 Zambia 185, 189, 411
 Zhang, K. 322
 Zhang, W. 391
 Zhang, Y. 322, 324
 Zhao, L. 340
 Zhou, Z. 323, 324
 Zilberman, D. 245
 Zimbabwe 104–105, 108, 185, 189
 technology spillovers and FDI
 411–15
 Zofio, J. 96

