Index

Agenda 21 113
‘aggregative approach’ 41
almost cooperative solution 106–10
arbitrage argument 39
asset accumulation equation 140

Bachelier, Louis 149
bang-bang control solution 13
basic economy with transboundary environmental problems
model 115–16
numerical results 116–21
sensitivity analysis 121–2
benchmark
independent price index 47
invariant price index 45–6
Brock model 9, 37
money metrics/utility metrics 30–32
non-autonomous optical control problem 10–13
social optimum and externalities in decentralized economies 16–30
stochastic version of 160–64
Brownian motion process 148–53, 161, 168
cost–benefit rule 164
capital
accumulation 17, 29
cost of 4
depreciation 115
income tax 71, 78, 79, 81, 85–7, 89
input 13–14
investments 19
shadow price of 20, 23–5, 146
capital market, restrictions on 88
capital stock
current value shadow price 21
equation of motion for 140–41
growth under uncertainty 153
probability distribution of 168
as state variables 10, 80
and technological progress 15
carbon dioxide pollution
data and parameters 125–6
decomposition of welfare measures 126–8
model 123–5
results 128–31
co-state
equation 35, 163–4
variable 18, 24, 82
Cobb–Douglas
instantaneous utility function 59, 124
production function 59, 115, 168
command optimum problem/solution 22, 30
competitive path 21–3
comprehensive net investment 44–5
conditional equilibrium 99, 100–104, 110–12
consumer
assets 75
behavior 123
demand 107–8
maximization problem 19–20
preferences 31
surplus 36–7, 39, 74
utility function 80
consumption
comprehensive concept of 1
external effects in 122–3
marginal utility of 24–5, 104
possibilities 2
present value of future changes 147
single homogenous good 16
utility value of 27, 77
consumption–investment pair 37–8
continuous-time
stochastic processes 148–52
stochastic Ramsey model 152–60
control
functions 11, 155, 156
problems 109
process 161–2
variables 10, 82
controlled market economy, welfare in 53 convex
differentiable cost function 17
feasibility set 13
cooperative solution 96–9, 100–101, 105–6, 110–12
cost–benefit analysis 9, 12–13, 25–30
cost–benefit rule 9, 17, 42–3, 51–3, 85–9, 102–6, 164–5
current value function 160
decentralized economies
applications 27–30
cost–benefit analysis 25–7
distortionary taxes in 75–7
externalities in 19–25
social accounting in 58
social optimum in 16–19
decentralized equilibrium 82
decentralized market solution 21–5, 100, 107
decision variables 10
differentiable value function 86–8
differential
equations 14, 26, 35, 39, 93, 169
games 8, 94, 134–9
discontinuities 12–13, 57, 109
discounting 10–11, 45
discrete estimation procedure 109
distorted market economies 2
distortionary taxation 7, 89
decentralized economies 75–7
green NNP analogue in second best environment 79–85
model and first best welfare measure 71–5, 77–9
distributional objectives 144–7
Divisa price index 44
domestic pollution 95–6, 107, 121
welfare 101
domestic producers, release of emissions 105
dynamic budget constraint 20
equilibrium models 6, 13, 81
tax 23–4
dynamic global economy models
numerical applications 113–14
basic economies 114–22
environment pollution and external effects in
production 122–32
economic behavior 2, 32
sustainability 44–5
Edgeworth, Francis Ysidro 41
emission function 29
permits 22
production function 72
technology 37
emission taxes 78–9
changes in 87–8, 105–6
design and implementation 48–68, 108
effect on employment 89
welfare consequences of 101–4
emissions
domestic producers 105
incentive to release 117
marginal cost of 88, 117, 130
rich countries 125–6
shadow prices of 16
socially optimal levels 16, 19
suboptimal generation of 102
employment 89, 139, 141–3
endogenous growth theory 13, 15
energy cost function 115
first order conditions for 73
input of 16–17, 20
producer 72, 75, 76
envelope theorem 43
environment assimilative capacity of 16, 27, 164
marginal damage to 104
environmental damage effects of 123
from production 111
environmental policies coordination of 92
effects on production decisions 104
environmental quality 106, 132
function 65
improvement in 98
indicator 93, 115
marginal utility of 117
relationship with pollution stocks 122
environmental taxes benefits of 22, 98
changes in 106
cost–benefit rule for 85–9
equilibrium
  in uncontrolled market economies 116–21
  trajectories 132
Euler condition 18–19, 23, 26, 28, 30, 38–9
external effects
  consequences for welfare measurement 116
  welfare contributions of 115, 117, 120–21, 122, 130–31
external effects in production 114, 122–3, 131–2
data and parameters 125–6
decomposition of welfare measures 126–8
model 123–5
results 128–31
externalities, decentralized economies 19–25
factor prices 103–4
feedback control
  in Stackelberg differential games 136–9
  welfare measurement under 135–6
feedback control law 155
final goods production 72, 75–6, 126
finite time horizon 25, 27, 124
first best
  deviation from 59
  equilibrium 58, 73, 74, 77, 139
  genuine saving 46
  growth path 15, 24
  optimization problem 83
  optimum 89, 147
  Pigouvian taxes 112
  resource allocation 7, 70
  solution 22, 100
first best welfare measure 18, 64, 70–75, 84
  and distortionary taxes 77–9
first order conditions 19, 23, 31, 35, 72–3, 136, 137
first order Taylor expansion 149
fossil fuels, use in production 124–5
future consumption, present value of 20
future damage, monetary costs of 25
future utility 167–8
  contribution to 109
interest on present value of 18–19, 21–3, 115
present value of 14, 72, 77, 83, 114, 120, 129, 140
static equivalent of 3–4, 83–5
future welfare
  approximations of 110
  effect of population growth 130
  present value of 146–7
  static equivalent of 44
future willingness-to-pay 30
general equilibrium solution 86
general multisector growth model 37–8
generalized comprehensive net national product (GCNNP) 41–2, 44
  relationship with genuine saving 46–7
  genuine saving 44–6
global economy, first best path of 22, 111
global economy, green accounting and taxes in 7–8, 91–2, 110–12
  almost cooperative solution 106–10
  cooperative solution 96–9
  market economy 99–106
  non-cooperative Nash open-loop solution 94–6
  two-country global economy 92–3
  welfare measures 131
  global welfare 96, 101, 102, 109, 111, 122
  global welfare measure 98, 108, 120, 121, 129
  government bonds 75, 80, 83
  green accounting 48–9, 67–8
  Pigouvian-related taxes 53–8
  practical applications 58–66
  welfare-improving non-Pigouvian taxes 50–53
  green accounting and distortionary taxation 70–71, 89–90
  cost–benefit rule for environmental tax 85–9
  welfare measurement 71–85
  green NNP 2–4, 5, 7, 109
  greenhouse gases, stock of 114, 123, 127, 130, 131
  growth theoretical approach 109
  approximation of 110
  effect of population growth 130
  present value of 146–7
  static equivalent of 44
  future willingness-to-pay 30

Hamiltonian
- augmented 19
- current value 3–5, 21–3, 98–9, 141–3, 146–7
- country-specific 121
- of first best problem 29, 53–8
- generalized 158, 160, 167–8
- maximized 43
- present value 18–19
- pseudo 29, 32, 58, 65–7, 77–9, 108–9
- human capital 59–60, 131, 132

imperfect competition in labor markets 139–43
income, marginal utility of 32, 37, 39, 40–41, 43
index numbers 41
indirect utility function 81
instantaneous social welfare function 144–5
instantaneous utility function 61, 65, 71, 93, 124, 139–40, 144
linear transformations of 31, 32, 74
money-metricized 36–42
interest
- on present value of future utility 115
- rate 75, 76, 81
intertemporal
- budget constraints 23
- economies 13
- index comparisons 37
investment, single homogeneous good 16
iso-elastic function 143
Ito
- calculus 148, 151, 168–9
- integrals 164–5, 168
Ito’s lemma 153–4, 158, 163
Jensen’s inequality 151

labor
- endowment 16
- force, growth of 153–4
- income taxation 71, 78–9, 81, 85–7, 89
- input 13–14
labor market
- competition 139–43
- restrictions on 88

Lagrange multiplier 81–2
leisure, social marginal value of 74, 139, 141–3
linear approximation 25, 74
linear emission production function 116
linear money-metricized index 35–6
linear transformations, instantaneous utility function 31–2
Lipschitz-continuity condition 135
lump-sum
- taxation 81
- transfers 20, 23

marginal cost
- of energy emissions/use 117
- of utility value of consumption 27
marginal environmental damage, monetary cost of 25
marginal externality, present value of 21–3
marginal product of labor, utility value of 139
marginal productivity 20
marginal technological progress 32, 160
marginal willingness-to-pay 22, 98
market
- baskets 40
- data 22, 24
- imperfections 2, 4–5, 6, 9, 131
market economy
- Pigouvian view 100–101
- special cases 104–6
- tax reform in the conditional equilibrium 101–4
market solution 21, 24–5, 28–9
Markov
- control 165
- property 150
maximization problem 11, 19–20, 22
‘missing information problem’ 101, 108
money discount factor 39
money-metricized instantaneous utility function 36–42
money-metrics
- consumer surplus in 39
- cost–benefit rules 42–3
- genuine saving 44–6
- green NNP in 74
- measure of welfare 24
- real NNP growth and welfare 24
relationship between GCNNP growth and genuine saving 46–7
static equivalent 42
welfare measurement in 30–32
monopoly union wage setting 142–3
multi-country economy 111
multi-region numerical general equilibrium model 125
multidimensional production possibility set 37

Nash feedback-loop games
differential games 136–9
model 134–5
non-cooperative differential games 91–2, 114–16
welfare measurement under feedback control 135–6
national accounts, augmentation of 59–61
national welfare 122
measures 96, 98–9, 120, 121
negative externalities 15
neoclassical
growth model 152
production function 37
net interest rate 81
net investments
measure of 1
physical capital 125
vector of 43
net national product (NNP) 1–2
No Ponzi Game (NPG) 20, 49, 50, 75–7, 142
non-arbitrage condition 18–19, 23, 26, 28, 30, 38–9
non-autonomous
dynamic growth model 9
optimal control problem 10–13
technological progress 13, 14, 15
time dependence 9, 13, 83, 98, 129, 139, 154–6, 168
non-cooperative
Nash equilibrium 116–17, 121–3, 125–8, 130
Nash open-loop game 105, 106
Nash open-loop solution 94–6, 99, 100–101, 110–11
non-Pigouvian taxes 48, 50–53, 67
numerical general equilibrium model 59–60, 87
objective function 10–11, 14, 75
of representative consumer 28–9
one-country economy 111
open-loop strategy 114–15, 116, 135, 136, 137
optimal consumption policy 154, 156, 158
optimal consumption-saving decision under uncertainty 152
optimal control problem 9, 137, 138, 165
time 11
optimal path, conditions for 11, 18–19, 31
optimal taxation 76
optimal value function 25–30, 31–2, 74, 86, 102, 156–7, 159
optimization problem 11–12, 17, 21, 23, 79–83, 97, 146–7
ordinal utility function 31
ordinary least squares 125
output per capita, rich countries 125–6

parameter
values 116, 126
vector 25
parametric change 9
partial differential operator 163
perfect competition 4, 20
perfect foresight market economy 15
perfect market economy 9
permit markets 22
physical capital 75
marginal utility value of 56
net investments in 72, 115, 125
shadow price of 63–4, 143
stock of 93, 100, 126
Pigouvian taxes 22–4, 28, 92, 98–101, 109, 112
approximation of 6–7, 53–8, 61–6, 100–101, 106–10

policy
instruments 82–3
mix 70, 89
projects 2–3
rules 70
policy reform 85, 117
welfare effects of 70–71
pollute decision to 100
pollution
  accumulation 16, 95–6, 116
  future marginal cost of 108
  marginal disutility of 61, 65, 84–5,
  104, 107, 121, 132
  shadow price of 53, 55–8, 61–2, 65–6,
  77, 85, 100–1, 122–5
  stock of 16, 21, 23–5, 29, 30, 67,
  77–8, 80, 87, 93, 117, 160–61
pollution control, marginal benefits and
  costs 99
poor countries 123–6, 129–31
population growth 124, 126–30
pre-reform
  emission tax 51–3, 88–9, 104
  equilibrium 106
preexisting
  policy 71
  tax distortions 87
private control variables 86
private sector 76, 79, 82, 85
production
  environmental damage from 111
  external effects in 114, 122–32
  factors 59–60
  functions 14, 16, 72, 124–6, 132,
  150–51
parameters 117, 120
possibilities 116, 123
technical complements in 29
technology 37, 121
use of fossil fuels 124–5
utility value of energy usage 19
welfare contribution of external effects
  131
profit maximization 16, 19–20, 108
publicly provided good 78–9, 82, 86–8
pure profit 20, 23
Ramsey growth model 9, 38, 152–6, 159,
  160
  welfare measurement in 13–15
Ramsey–Brock problem 36
reaction function 137
real wages 20
real-world market data 122–3
Regional Integrated Model of Climate
  and the Economy (RICE) 125
representative agent models 104–5, 144–5
resource allocation 85, 94, 114–15, 117,
  123
resources dependent economy 45
rich countries 123–6, 129–31
second best environments, green NNP
  analogue in 79–85
second best optimum 89
second best problem 82
second best welfare measures 84, 85
second order Taylor expansion 150
sensitivity analyses 116, 130–31, 132
separability assumption 104
single homogeneous good 16
smooth strategies 135
social
  value of environmental improvements
  98
  welfare function as a utility sum 130
social accounting theory 1–2
  practical implications 58
  relevance of imperfections 59–61
  usefulness of Pigouvian-related taxes
  61–6
social accounting, emerging issues
distributional objectives 144–7
labour market competition 139–43
Nash feedback-loop games and
  Stackelberg games 134–9
social optimization problem 136
social optimum 17–19, 21, 23–5
socially optimal
  path 110
  policy 146
  resource allocation 145, 146, 147
Solow neoclassical differential equation
  153
Stackelberg differential games 76,
  134–9
state process 161–2
state variables 163–4
  equations of motion 96–7
  vector of artificial 25
static
  index 111
  indicators 1
  optimization problem 165–7
  theory 25, 31
willingness-to-pay 53, 66, 100, 109–10
stationary technology 4, 145
stochastic
  Brock model 160–64
  control theory 168–9
  processes 148–52
  Ramsey model 152–6
  welfare measure 168
stock externalities 101, 107
stock option pricing theory 149
stocks, net changes in 1–2
Stratonovich integral 168
suboptimal
  distribution 144, 147
  equilibrium 85
  value function 28–9
Swedish Energy and Environment Policy (SEEP) model 61, 62–3
tax
  bases 86–7
  mix 71, 85, 89
  policy 110
  rates 80, 82
  tax reform 85, 92, 102, 106, 111
    in the conditional equilibrium 99, 101–4
  tax revenues, lump-sum transfer 23–5,
    74–5, 100, 102
  technological change 128–9, 131, 132
    influence on production 124
    rate of 126
    value of 60–61
  welfare contribution of 2, 129, 130, 131
  technological progress 15, 32
    non-attributable 159–60, 168
    rate of 14
    relative importance of 32
    shadow value of 18
    uncertainty about 152
    welfare contribution of 32
  time dependent
    discount factor 10, 11, 13
    lump-sum transfer 20
  time preference 19
transboundary environmental problems
  7, 114–15
  model 115–16
  numerical results 116–21
  sensitivity analysis 121–2
  transversality condition 20, 24, 27, 84,
    100, 162, 164
two-country
  global economy 92–3
  two-point boundary problem 137–9
uncertainty, welfare measurement under
  8, 156–60, 167–9
  continuous-time stochastic processes 148–52
  continuous-time stochastic Ramsey model 152–6
  cost–benefit rules 164–5
  HJB equation 165–7
  stochastic Brock model 160–64
uncontrolled market economies 16, 19, 110, 114–16, 117, 120–21, 123, 130–31
  equilibrium in 116–21, 125, 127–9, 130
  welfare in 53, 122
unemployment 139–43
unintenalized external effects 59, 79, 96, 111, 122, 130
unit tax 22
United Nations Conference on Environment and Development (UNCED 1992) 113
utilitarian social welfare function 124
utility 35–6, 39
  distribution across individuals 144
  maximization, first order conditions 31
  metrics 30–32
  present value shadow prices of 94
  revenues in terms of 27
  value of 18–19, 57
utility discount factor 39, 78, 83, 98, 145
  rate 83, 88–9, 120–22, 126, 129, 135, 139
utility functions 39–41, 67, 74, 80, 86–7, 111, 144, 155–6
  first order approximation of 24
  linear approximation of 34–5
  maximization of 13, 102
  monotone transformations of 31, 36
  non-linear 110
  parameters of 126
  properties of 123
utility metrics, welfare measurement in 30–32
value function 86–8, 109, 165
   envelope properties of 94

wage rate 74–6, 139–43
wage setting 142–3
wealth 20
   marginal utility of 79–81, 83, 88
   shadow prices of 89
   utility value of 77
Weitzman’s welfare theorem 3–4, 5, 9, 30–32, 34–42
   cost–benefit rules 42–3
   genuine saving 44–6
   real NNP growth and welfare 44
   relationship between GCNNP growth and genuine saving 46–7
welfare
   analysis 130

approximation of 24–5
overestimation of 61
welfare measurement
   money metrics/utility metrics 30–32
   Nash feedback-loop games/
      Stackelberg games 134–9
   Ramsey growth model 13–15
   under distortionary taxes 71–85
welfare measures
   biases of 130
   decomposition of 126–8
   estimated contributions of 132
white noise 153, 159
Wiener process 149
willingness-to-pay 25, 48, 55, 58, 67, 84, 106–7, 109–11
Young’s theorem 52