

## Index

Page numbers in *italics* and **bold** refer to figures and tables, respectively

- adaptive learning, 101–2
- adaptive resilience, 171, 202
- Adversarial Perspective Team (APT), 648–51, *649*
- adversarial risks, predicting and
  - quantifying, 102–5, 732
  - with unknown probabilities and scarce data, 99–102
  - using BN, ID, or nested decision-tree models, 94–99
- adversary decision making
  - behavioral approaches to, 580–86
  - modeling, 587–88
    - attacker’s expected utility accounting for risk attitude, 584–85
    - attacker’s expected value, 584
    - lens model, 585
    - multiattribute utility (MAU) model, 585–86
  - robust approaches to, 577–80
- Al Qaeda, 111, 376, 379, 709, 713, 722–23
  - terrorist objectives of, 383–91, 385, 392–93
    - related to establishing a Caliphate, 390–91
    - related to killing enemies, 391
    - related to religion, 388–89
    - related to territory and power, 389–90
- al Zarqawi, Abu Musab, 384
- algorithm
  - ARMOR system for Los Angeles International Airport, 630, 634–35
  - ellipsoid algorithm, 607
  - interval security game (ISG), 524–26
  - linear-time algorithm for finding SSE, 515
  - no-regret algorithms, 618
  - polynomial weights algorithm, 619
  - regret algorithms, 618
  - Upper Confidence Bounds for Trees (UCT) algorithm, 614
- Al-Sharif, Sayyed Imam, 383
- alternative probabilistic causal chains, 62–63, 75
- Analytic Hierarchy Process (AHP), 398
- anchoring bias, 582–83
- anti-terrorism modeling, Bayesian networks, 24–25
- approximation, 85
- arbitrary methods of decision making, 397–98
- Archimedean utility copula, control strategies of, 435–38
- ARMOR system for Los Angeles International Airport, 491–92, 628–30, 634–38, 667–68
  - algorithmic goals, 634–35
  - assumptions about attacker’s rationality, 634
  - assumptions in, 645
  - developing a defensive measure, 632
  - DOBSS algorithm, 630
  - human trials, 645–46
  - implementing solutions, 635–36
  - mathematical sensitivity analysis, 642–44
  - modeling deterrence, 632–33
  - optimality proofs, 634
  - PASAQ strategy, 641

- ARMOR system for Los Angeles (*cont.*)  
 previous scheduling practices, comparison of, 636–41  
 qualitative expert evaluations, 650  
 quantal response (QR) model of an adversary, 640–41  
 quantitative data analysis, 646–47  
 scheduled checkpoints, 632, 634–35  
 schedules against human opponents, 646  
 scheduling for FAMS domain, 638, 640  
 specific security problems identified, 629  
 threat deterrence, 666
- asymmetric prescriptive/descriptive game theory, 731  
 in counterterrorism decisions, 731–32
- attack alternative ranking, 722–23, 723, 723, 723
- attack probabilities ( $P(A)$ ), 9
- attack trees, 17–18
- attack type strategies, **715**  
 attacker's expected utility accounting for risk attitude, 584–85  
 attacker's expected value, 584  
 by proxies, 724, 725, 725
- Augustine's Law, 60
- Aumann, Robert, 26
- availability heuristic, 264
- aversion, 172
- aversion behavior and return of evacuated population, 180
- al-Zawahiri, Aiman, 383
- back-of-the-envelope (BOTE), 161
- Bayes' rule, 25, 95, 101, 396
- Bayesia®, 96
- Bayesian Model Averaging (BMA), 101–2
- Bayesian networks (BN), 12, 18, 24–25, 27, 86  
 in adversarial risk analysis, 94–99  
 anti-terrorism modeling, 24–25  
 DAG structure of, 97  
 ID models, 98  
 for patient health status, 97  
 quantifying probability distributions of unknown quantities, 94–98  
 second-order probability distributions for, 100
- Bayesian Stackelberg games, 519–21, 540, 670  
 addressing multiple types of attackers, 589  
 robust, 589–90
- Bayesian updating, 583
- behavioral research, 3
- belief nets, 11
- benefit-cost analysis, 2
- best mixed strategy in hindsight, 617
- Biological Agent Risk Analysis, 5
- Bioterrorism Risk Assessment (BTRA), 6, 65  
 background, 2006, 6–7  
 disclosure of shortfalls and risk management, 78  
 event tree, 14–15  
 model for attacker's and defender's choices, 8
- blast effects and acute radiation, 124
- Boolean algebra, 17
- bound queries, 622
- bounded rationality, 173, 200, 502
- bounded unbiased estimate, 620
- buffer capacity, 196
- Bureau of Transportation Statistics (BTS), 223
- business interruption (BI), 202
- capturing risk-generating process in TRAMs  
 alternative probabilistic causal chains, 62–63  
 initiation process, 61  
 scenario-shaping process, 61–62  
 unanticipated scenarios, 62
- causal loop diagrams, 22–23
- Center for Risk and Economic Analysis of Terrorism Events (CREATE), 1–2, 193–94, 261, 351
- chance constrained model (CCP), 151–53
- chemical, biological, radiological, and nuclear (CBRN)  
 threats, 194  
 weapons, 262
- Chertoff, Michael, 344, 445
- Chevron Project Development & Execution Process (CPDEP), 334–36, 335–36  
 decision quality at Chevron, 337–38
- Chicago's O'Hare Airport, case of insuring, 265–66
- choice rule, 410, 412
- Cobb–Douglas production functions, 160
- cognitive biases, 581–83
- collision avoidance, 433–34
- Columbia accident, 745
- Commodity Flow Survey (CFS), 223

- community
    - defined, 197–98
    - resilience, 197–98
  - comparative risk analysis (CRA), 32–33
    - assessment of homeland security risks, 39, 39–40
    - goal of, 33
    - interpreting results of risk-ranking sessions, 49–50
    - risk rankings, conducting
      - carrying out sessions, 43–48
      - recruiting participants, 41–43
    - steps, 34, 35
      - presentation of risks, 38–40
      - risk attributes, selecting, 36–38
      - risk categorization, 35–36
      - risk summary sheets, 39, 39–40
  - computable general equilibrium (CGE)
    - models, 158, 209, 278
    - advances in, 161
    - basic design of, 161–70
    - Cobb–Douglas production functions in, 160
    - computational requirements for, 161
    - dynamic nature of, 160
    - equations, 165–67
    - example, 176–85
    - extensions to incorporate
      - behavioral linkages, 172–73
      - resilience, 170–72
    - flexibility and realism, 159–60
    - households in, 158–59
    - input–output balance conditions, 165
    - input–output database for, 162–66, 163
    - Johansen’s, 158–59
    - of macroeconomic impacts, 308–9
    - price and quantity movements, 166–70
    - in regression analysis, 170
    - of United States, 161
    - USAGE and USAGE-TERM, 173–76
  - computational game theory, 497
  - conceptual model validation, 55
  - conditional disutility function, 419
  - conditional expected value, 104
  - conditional probability table (CPT), 96
  - conservatism bias, 581–82
  - constant elasticity of substitution (CES)
    - production functions, 160, 304
  - contagion, 173
  - control theory, 1
  - cost-benefit analysis, 667
  - counterterrorism experiment, 659–64
  - counterterrorism strategies, 393–94
  - coverage vector, 514
  - CPLEX commercial solver, 137
  - credal networks, 100
  - cross-border trips and wait time, 290–94
  - cumulative utility distributions (risk profiles), 724, 725
  - cybersecurity, 748
  - decision analysis, 2, 8, 15, 27, 242–5, **253–4**, 324–5, 327, 335, 337, 386, 396, 414, 422, 445–6, 731–2. *See also* risk assessment in evaluation of terrorist threat
  - Decision Conferencing, 332
  - decision making
    - adversary decision making
      - behavioral approaches to, 580–86
      - modeling, **587–88**
    - attacker’s expected utility accounting for risk attitude, 584–85
    - attacker’s expected value, 584
    - lens model, 585
    - multiattribute utility (MAU) model, 585–86
    - robust approaches to, 577–80
  - arbitrary methods of decision making, 397–98
  - majority-vote criterion *vs* individual attributes, 398–400
  - min–max regret criterion, 400–405, 402
  - statistical variations, 328–29
  - using multiattribute value and multiattribute utility functions, 409–24
  - “weight and rate” choice criterion, 405–9
- decision processes, common, 331
- decision quality chain, 326–27
  - alternatives, 327, 341
  - commitment to action, 327, 341
  - elements of, 397
  - frame, 327, 340
  - information, 327, 341
  - logical reasoning, 327, 341
  - values, 327, 341
- decision support systems for security
  - descriptions of deployed, 628–31
  - formulating a model, 631–36
    - efficient algorithms, 634–35
    - implementing solutions, 635–36
  - of real-world problem, 632–33
  - solution concepts and computational methods, 633–35

- decision support systems for security (*cont.*)  
 goals for, 664–66  
   cost-benefit analysis, 665  
   threat deterrence, 665–66
- decision trees, 11, 14, 14–16, 404, 452–61,  
 453, 476, 478  
 analysis of, 461–65, 462–64  
 application of, 15  
 assumptions in, 16  
 base case parameters and ranges, **454–56**  
 branches, 14–15  
 endpoints, 15  
 leftmost node in, 14  
 in terrorism context, 15
- decision-driven organization, 328–29  
 steps on focus on decision making, 328–29
- decomposition theorem, for multiattribute  
 utility functions, 422
- deep uncertainty, 85
- defender-attacker decision trees, 446–50, 449
- defenders  
 expected payoff of, 522–23  
 mixed strategy of, 512  
 risk aversion, 104  
 uncertainties, 88–89
- defensive resource allocation  
 among multiple potential targets (equity  
 coefficient), 694–703  
 cost-effectiveness of defense, 700  
 data sources, 697–98  
 model formation, 696–97  
 optimal allocations, 701–2  
 sensitivity analyses of equity funding  
 distribution, 698–700  
 model formulation and data sources, 683–84  
 numerical illustrations, 684–89,  
**685–87, 688**  
 robustness analyses, 689–94  
 sensitivity analyses, 692–94, 693
- defensive strategies, 88
- Deliberative Method for Ranking Risks, 34,  
 37–38, 50
- deliberative thinking, 264
- delivery mode of dirty bomb, 117
- Department of Homeland Security (DHS), 32,  
 445, 727  
 Biological Agent Risk Analysis, 5  
 Bioterrorism Risk Assessment (BTRA), 6–7  
 homeland security objectives, 345  
 risk management philosophy of, 344  
 task of, 344  
 value model of, **345–6**
- appropriateness of adding values of  
 achievements, 356–58  
 appropriateness of linearity, 358–60  
 assessing value trade-offs, 360–66  
 combining impacts on different  
 objectives, 356–60  
 construction of, 350–66  
 in developing severity index for terrorist  
 consequences, 369–71, **370**  
 in evaluating benefits of  
 countermeasures, 368  
 in evaluating terrorism risk, 367  
 identifying and organizing objectives,  
 350–51, **352–53**  
 short-term and long-term effects of, 371–73  
 specifying metrics to measure objectives,  
 353–56, **354–55**  
 uses of, 367–73  
*See also* value model
- deterministic BCA (DBCA), 247, 249  
 assumptions in, **255**
- deterministic model (DP), 151–53
- deterministic multiattribute decision  
 problems, 414–16
- deterrence effect, 457–58
- detonation site of dirty bomb, 117–18
- Dialogue Decision Process, 330, 332
- Direct Dynamic Economic Resilience  
 (DDER), 209
- Direct Earned Premium (DEP), 266
- Direct Economic Loss Module (DELM), 210
- direct infrared countermeasures  
 (DIRCMs), 450
- Direct Static Economic Resilience  
 (DSER), 207–9
- directed acyclic graph (DAG)  
 representation, 105  
 of a BN model, **97**  
 of dependency relations, 96
- dirty bomb attacks, analysis of, 1, 9, 11, 21  
 challenges in procuring radioactive  
 material, 111–12  
 consequences of, 123–28  
   blast effects and acute radiation, 124  
   economic, 126–28  
   health effects, 124–26  
 countermeasures, 128–29
- delivery modes, 117
- detonation site, 117–18
- impacts of, 111–12
- on the Los Angeles and Long Beach  
 harbors, 115–16

- probabilities of success, 119–23
- pruning scenarios and assessing relative likelihoods, 118
- ranges of consequence estimates, **123**
- reasons for using, 111
- transportation and location scenarios, **119, 120**
- type of dirty bomb constructed, 117
- vulnerable tasks of the medium scenario, *121*
- disagreement, 85
- disaster resilient, 201
- DOBSS algorithm, 630
- dynamic economic resilience, 202, 204–5
- dynamic resilience, 171, 202
- dynamic systems, 1
- economic consequence analysis, 2
  - See also economic impact analysis
  - economic impact analysis, 225–34, 291
  - of CBP inspection staffing changes, 307, 309–10, 312–14, **313**, 317n2, 319n26
  - of changes, 283–85, **286**
  - of transport costs, 304–5
  - using NIEMO, **224**
- economic resilience, 196
  - basic attributes, 201–5
  - behavioral considerations, 204
  - capacity, 202–3
  - conservation options, 203
  - Draconian conservation, 203, 211
  - dynamic, 202, 204–5
  - of Japanese industries, 211
  - at macroeconomic level, 204
  - measurement of, 210–12
  - at mesoeconomic level, 203–4
  - static, 202–5
  - in terms of function, 202
  - time-path of, 205–7, *206*
  - See also resilience
- ellipsoid algorithm, 607
- EnviNIEMO, 223–25
- Environmental Protection Agency, 33
- $\epsilon$ -optimal response strategy, 578–79
- equitable resource allocation, 682–83
- equivalence rule (von Neumann Morgenstern utility rule), 409, 413
- ERASER-C, 533–35
- evacuations and labor supply, 177–78
- evaluations
  - case studies
    - Adversarial Perspective Team (APT), 648–51, *649*
    - comparison with previous best practices, 636–41, *638–40, 642*
    - mathematical sensitivity analysis, 642–44, *643, 645*
    - qualitative expert evaluations, 650–52
    - quantitative data, 646–48, *648*
    - real-world evaluations, 652–64
    - solutions to variations in human behavior, 645–46, *646*
  - cost-benefit analysis, 667
  - human behavioral experiments, 668
  - model-based/algorithmic, 666–67
  - operational record of a system, 668–69
  - real-world
    - counterterrorism experiment, 659–64
    - fare evasion experiment, 652–59
  - relative benefit of defensive measures, 667–68
  - security applications, in context of, 628–31
- event trees, 11
  - applications to terrorist risk assessment, 17
  - operation of, 13–14
  - properties of, 13
  - for a very large complex system, 14
- ex ante equity, 682
- ex post equity, 682
- expected utility maximization, 409–12
  - in direct result of the rules, 410–11, *411*
  - formulations for decisions with multiple attributes, 412–14
- expected-utility theory (EUT), 730
  - typical utility function, *736*
- expert rankings, 42–43, *43*
- exposure to radioactive material, health effects, 124–26
- extensive-form games, 446
- facility location model, 136, 141–47
  - attributes considered, 142–43
  - example, 145–47, *147*
  - maximal covering location problem (MCLP), 144
  - multiple quantity coverage requirements, 145–46
  - number of quality levels and quantity, 144
  - objective of maximizing the demands, 144
  - selection of eligible facility sites, 143
- fare evasion experiment
  - experiment setup, 653–55
  - results, 655–59, *658*

- fare evasion experiment (*cont.*)
  - game theory vs uniform random, 657–59
  - GT and UR schedules, 653, 655–59
  - validation of the MDP model, 657
- fault trees, 11, 17–18, 18
  - generic, 20
- Federal Air Marshals Service (FAMS), 630, 636, 638
- Federal Aviation Administration's (FAA), 263
- Federal Bureau of Investigation, 32
- Federal Emergency Management Agency (FEMA), 338
- finite-horizon MDP, 615
- fish protection for the U.S. Coast Guard, 600
- Flexible National Interstate Economic Model (FlexNIEMO), 228–32
  - empirical, substitution-driven changes, 229
  - month-to-month output changes, **233**
  - results, 232–34
- Flexible NIEMO (FlexNIEMO), 222
- fraud detection, 672
- full-scale exercise (FSE), 659
- game theoretic models, 25–27, 670–71, 691
  - assumptions in, 25
  - as a normative technique, 26
  - useful applications of, 26
  - for worst-case consequences for terrorism scenarios, 25–26
- game theory, 1–3, 12, 15, 25–27, 85, 251, 446, 485, 497, 577, 628, 630, 634, 734
  - mixed strategy, use of, 510
  - notion of equilibrium in, 521
  - real-world effects on standard assumptions of, 574–77
- Game-theoretic Unpredictable and Randomly Deployed Security (GUARDS), 494
- GEMPACK, 169
- generic fault tree, 20
- Genie™, 25
- Gini coefficient, 683
- Global Trade Analysis Project (GTAP), 161, 303
  - balance between global imports (CIF values) and exports (FOB values), 303
  - economic impacts on transport costs, 304–5
  - trade and transport in, 303–4
- green security games, 488–89
  - applications, 496–98
  - See also* security games
- gross state product (GSP), 220
  - contributions to percent change in, 2004–2005, **221**
- ground shine, 126
- group equity, 682
- Harvard School of Public Health, 42
- hazard loss estimation, 2
- hazard-resilient communities, 200
- HAZUS Indirect Loss Module (IELM), 210
- health effects of dirty bomb attacks, 124–26
- heuristic weighted randomization, 636
- Holt-Winters time-series approach, 228
- homeland security decisions, 4
- Homeland Security Institute, 12
- Homeland Security Presidential Directive (HSPD) 10, 6–7
- homeland security risk, common
  - expression of, 9
- horizontal equity, 682
- human behavioral experiments, 668
- Hurricanes in the Gulf of Mexico, temporal
  - economic impacts, 225–34
    - changes of actual and estimated oil refinery values, 229
    - negative impacts of oil refinery losses, 232
    - paths of, 226, 227
    - petroleum production pre- and post-Katrina and Rita, 227
    - total economic impacts, 231–32
- ideal risk-ranking systems, 36
- Impact Analysis for Planning (IMPLAN) System, 307
- individual equity, 682
- individual resilience, 196–97
- influence diagrams, 11, 18–21, 86
  - example, 21, 21
  - for terrorist decisions, 87
- information theory, 1
- infrastructure security games, 488
  - applications, 491–96
  - See also* security games
- inherent randomness or unpredictability, 85
- inherent resilience, 171, 202
- input–output (I–O) models, 158, 220
  - Leontief, 222–25
  - matrix form of an economy, 222
- insurgent stock and flow diagram, 23
- intelligence community (IC), 7–8, 86

- intelligence information, 10–11, 16–17  
 intelligent adversary analysis, 7–8  
 interdependent security, 263  
 International Atomic Energy Agency (IAEA), 111  
 interval security game (ISG), 521–26  
   algorithm, 524–26  
   analysis of, 522–24  
   defender's expected payoff, 522–23  
   maximum attacker payoffs, 524  
   minimal coverage for target, 523–24  
 intuitive thinking, 264  
 inventory management model, 136–41  
   brief summary of, 138  
   cases for combined inventory policy, 139  
   example, 140–41  
   first-in-first-out (FIFO) policy and prices, 138  
   inventory cycle  $T_{inv}$ , 138  
   possible combinations of fresh inventory and previous inventory, 138–40  
   problem parameters and profit analysis, 140, 140–41, 141  
   regular EMQ cycle, 138  
   types of demand, 138  
 IRIS for U.S. Federal Air Marshals Service, 492–93, 631  
   design, 630  
   human trials, 645–46  
   qualitative expert evaluations, 651  
   quantal response (QR) model of an adversary, 640–41  
   schedules, 630  
 Islamic State of Iraq and the Levant (ISIL), 377, 379  
   terrorist objectives of, 383–91, 388, 392–93  
     related to establishing a Caliphate, 390–91  
     related to killing enemies, 391  
     related to religion, 388–89  
     related to territory and power, 389–90  
 ISO Standard 15288, on “Systems and software engineering, 55  
 K9 units, 629, 665  
 Kahneman, Daniel, 264  
 Laden, Osama Bin, 376, 383–84  
 lamppost effect, 36  
 large-scale emergencies  
   defined, 134  
   distribution problems, 147–54  
   distribution process of, 135, 135  
   interconnected key decisions in, 136  
   initial prepositioned supplies, 137  
   problem decomposition for emergency response, 136  
   problem of routing inventory in, 148  
   storage problems, 141–47  
 large-scale linear programming  
   methods, 546–64  
 Leontief technical coefficients, 222  
 Leontief's technology, 158  
 linearization errors, 169  
 linear-time algorithm for finding SSE, 515  
 Linear-Time Resource Allocation (LTRA), 517–19  
 linguistic imprecision, 85  
 LocAlloc heuristic, 146  
 logic trees, 12–18  
   limitations, 15  
 Los Angeles Sheriff's Department (LASD), 652–53, 662  
 Los Angeles World Airport (LAWA)  
   police, 629–30  
 loss-aversion equilibrium (LAE), 731  
 losses estimation, from terrorist attack scenarios, 269–73  
 Luce's Choice Axiom (LCA), 583  
 Lyapunov-type functions, 428  
 macroeconomic models, 209  
 majority-vote criterion vs individual attributes, 398–400  
 Maktab al Khidamat, 383–84  
 Man-Portable Air Defense Systems (MANPADS), 11, 446–47, 450–52  
   Command Line of Sight and Laser-Beam Rider (CLOS/LBR), 451  
   decision tree, 452–61, 453  
   Infrared (IR), 451  
 marginal probability tables, 96  
 Markov Decision Process (MDP), 615  
 Markov population processes, 679  
 master problem, 530–31  
 maximum equity, 683  
 maximum regret of defender strategy, 401–3, 403–4, 410, 622  
 max–min equity, 683

- membership oracle, 608
- meta-choice and specification within benefit-cost analysis
  - aggregation across economic actors, 249
  - general vs partial equilibrium, 248
- Microsoft Project®, 119, 120
- MIDAS, 589–590
- MIL-STD-3022 on Verification, Validation, and Accreditation (VV&A) for Models and Simulations, 55
- minimum cost network flow (MCNF) problem, 532
- minimum equity, 683
- min–max regret criterion in decision making, 400–405, 402
- mixed strategy, 510
- model uncertainty, 85
- model-based/algorithmic evaluations, 666–67
- Monte Carlo simulation, 95, 722, 723
- Monte Carlo Tree Search (MCTS), 612–16, 613
- multiattribute utility copulas, 428–32
- multiattribute utility functions
  - basic expansion theorems for, 418–23
  - decomposition theorem for, 422
  - using value functions, 416–18
- multiple decision makers, 586–90
- multiplier values, 209
  
- NASA Space Shuttle PRA, 14
- Nash equilibrium, 510, 539, 633
- National Atmospheric Release Advisory Center (NARAC), 124
- National Cooperative Highway Research Program study, 301
- National Infrastructure Protection Plan, 37
- National Intelligence Estimate (NIE 29–51) (document), 10
- National Interstate Economic Model (NIEMO), 220, 222–25
  - economic impact studies using, 224
  - environmental models (EnviNIEMO), 223–25
  - as operational MRIO model, 223
  - transportation network system (TransNIEMO), 223
- National Research Council (NRC), 5–6, 27, 103
  - review of BTRA in 2006, 7
- near-miss events, 746–48
  - cybersecurity example, 748
  - discussion, 757–58
  - subjective interpretation of events, study of
    - discussion, 757
    - materials and method, 754
    - results, 755–56, **756**
  - system’s resilience (failure averted) and its vulnerability, study of, 748–53
    - discussion, 753
    - materials and methods, 749–51
    - results, 751–52, **752**
- Netica™, 25, 96, 98
- 9/11 terrorist attack, 1, 172, 195, 207, 259
  - See also dirty bomb attacks, analysis of no-regret algorithms, 618
- normal-form game (NFG), 509
- North American Free Trade Agreement (NAFTA), 303
- North American Industrial Sector Code (NAISC) system, 223
- notional bioterrorism event tree, 18–19
- Nuclear Regulatory Commission (NRC), 114
  
- Office of Management and Budget (OMB), 239–40
- one-kiloton nuclear detonation in Downtown Los Angeles, economic effects of
  - impacts, 181–84, 181–85
  - setting up USAGE-TERM and specifying shocks, 176–77
    - affected population, 177
    - affected surviving population, 177
  - aversion behavior and return of evacuated population, 180
  - evacuations and labor supply, 177–78
  - impact area, 177
  - later deaths, morbidity and labor supply, 178–79
  - medical costs, 179
  - public-sector deficit and foreign debt, 180
  - radiation clean-up and decontamination cost, 179
  - shutdown period, 177
  - treatment of capital, 179
- operational MRIO model, 223
- operational record of a system, 668–69
- operational validation, 55
- operations research, 1
- operations research models, 134



- operations research (OR) techniques, 678–80
- opportunistic crime security games, 489–90  
 applications, 498–99, 499  
*See also* security games
- optimal risk-reduction strategy, 103
- order rule, 409, 413
- organizational behavior, 199–200
- Organizational Decision Quality (ODQ), 329  
 appropriate decision processes, 330–33  
 decisions *vs* outcomes, 325  
 education and training, 333–34  
 elements of, 326  
 enabling, 329–36  
 learning and continuous improvement, 336  
 Raiffa-Howard Award for, 336–38
- organizational theory, 200
- ORIGAMI, 514
- ORIGAMI-S, 533
- Padilla, Jose, 111
- partial information feedback model, 621
- PAWS for Wildlife Security, 599–600
- payoff matrix, 509
- plural analysis, 102
- polynomial weights algorithm, 619
- population wellness, 198
- Port Resilience Operational/ Tactical  
 Enforcement to Combat Terrorism  
 (PROTECT) model for U.S. Coast  
 Guard, 485, 493–94, 493–94, 599,  
 629–30, 634
- Adversarial Perspective Team (APT)  
 observations, 648–51, 649
- design, 630
- Maritime Security Risk Assessment  
 Model, 652
- Ports, Waterways, and Coastal Security  
 (PWCS) Mission, 630
- quantal response (QR) model of an  
 adversary, 640–41
- quantitative data analysis, 647–48
- robustness of PASAQ solution concept *vs*  
 defender strategy, 644, 645
- solution concepts, 631
- USCG patrols before and after deployment,  
 647–48, 648
- Ports, Waterways, and Coastal Security  
 (PWCS) Mission, 630
- ports of entry (POEs), 277
- potential points of dispensing (PODs), 135
- probabilistic risk analysis (PRA), 5–27, 98, 678
- for assessing terrorism risk, 8–11
- Bayesian network analysis, 24–25
- causal loop diagrams and systems dynamic  
 models, 22–23
- common arguments against use of, 10
- game theory models, 25–27
- influence diagrams, 18–22
- logic trees, 12–18
- NASA, 14
- probability of an attack, 456–57
- probability rule, 409
- probability trees model, 12–13, 13  
 properties, 12  
 uses, 12–13
- project-risk analysis, 99
- proportional equity, 683
- prospect theory (PT), 730–37, 733  
 existing work on, 737–38  
 impacts of modeling adversary with  
 preferences, 738–41  
 probability weighting function, 737
- Protection Assistant for Wildlife Security  
 (PAWS), 497
- proxy experts, 88
- proxy utility model  
 applications, 727  
 attack type strategies by proxies, 724, 725, 725  
 challenges, 726–27
- psychometric paradigm, 37
- Public events, protection of, 496
- public resource allocations, 683
- Python, 96
- Quadrennial Homeland Security  
 Review, 42, 50
- Quantal Response Equilibrium (QRE), 583
- quantal response (QR) model, 502, 561,  
 583–84, 599, 622, 640–41, 731
- queueing theory, 679
- R programming, 96
- radioactive material  
 challenges in procuring, 111–12  
 sources of, 113, 113  
 foreign, 114–15  
 medical, research, and industrial  
 facilities, 114  
 nuclear power and waste facilities, 114  
 blast effects and acute radiation, 124  
 radiation clean-up and decontamination  
 cost, 179

- radioisotope thermoelectric generators (RTGs), 115
- Raiffa-Howard Award, 336–38
- real-world effects in game theory, 574–77
  - execution and observation assumption, 577
  - information assumption, 576–77
  - rationality assumption, 576
- regression-based econometrics, 170
- regret of the algorithm, 618
- relative benefit of defensive measures, 667–68
- reliability theory, 17
- resilience, 170–72, 194–95
  - approach to measuring and evaluating, 212–13
  - community, 197–98
  - definition of, 193
  - ecological origins, 196
  - economic incentives and, 196
  - engineering-based definitions, 198–99
  - etymology of, 195–201
  - indices, 212–14
    - reasons to construct, 213
    - short-run economic, 213
  - individual, 196–97
  - in Norris framework, 198
  - organizational behavior and, 199–200
  - planning and, 200–201
  - in terms of reduction in property damage, 195
- Resilience Alliance, 199
- resilient cities, 201
- resilient near-miss events, 747–48
- risk, in design and implementation of a
  - benefit-cost analysis, 247–48
- risk analysis, 1–2, 129, 241–42, **254**, 327, 345, 446–47, 534, 670, 697, 711
  - equity considerations in, 682–83
  - intelligent adversary analysis, 7–8
  - Risk Analysis* article, 54, 57, 61
  - See also* adversarial risks, predicting and quantifying; comparative risk analysis (CRA); probabilistic risk analysis (PRA); terrorism risk, quantifying
- risk assessment in evaluation of terrorist threats
  - attack type strategies, **715**
  - attribute definition and measurement, 717–19, **719**
  - context, 710–11
  - decision maker and context, 712–13
  - decision tree probability estimates, 715–17
  - long-term economic impact certainty equivalent, 720
  - MAU modeling approach, 711–12
  - normalized swing weight assessments, 721, **722**
  - risk attitudes across attributes, 720–21
  - SME proxy assessment, 714
  - terrorists' fundamental objectives
    - hierarchy, 713
    - value trade-offs across attributes, 721
  - risk attitudes across attributes, 720–21
  - risk attributes, 36–38
    - in ideal risk-ranking systems, 36
    - literature-based approach in selecting, 37–38
    - participants' individual perceptions of, 45
    - sorting of, 45–46
  - risk categorization, 35–36
    - by area, 35–36
    - by hazard, 35–36
    - of homeland security risks, 35
    - of specific risks, 36
  - risk management decision-making process (DMP), 64–68
    - identifying best feasible jobs, 67–68
    - risk reduction measures, 66–67
    - during uncertainties, 66
  - Risk Management Solutions (RMS), 270
  - risk matrices, 103
  - risk rankings, conducting
    - carrying out sessions, 43–48
      - attributes ranking, 45–47
      - hazards ranking, 47–48
      - materials to support, **44**
    - interpreting results of risk-ranking sessions, 49–50
      - final ranking, 50
      - primary outcomes, 49
      - secondary outcomes, 49
      - standard deviation of rankings, 49–50
    - recruiting participants, 41–43
      - from expert populations, 42
      - from general public, 42
      - using sampling techniques, 42
    - risk-ranking sheets, 48
  - Risked BCA (RBCA), 247, 249–50
    - degree of model fit, 252
    - estimation of probability, 251
    - impact of stochastic randomness or pure error in, 251–52
  - risk-informed benefit-cost analysis, 238–39
    - aggregation analysis, 244–45
    - Department of Homeland Security context, 240–42
    - threat and hazard types, **241**

- deterministic, 249
- goal and associated metrics, 244
- implementation of risk concepts, 247
- meta model choice, 242–49
- models and metrics, 242, **253–54**
- performance metrics for, 249–50
- preferences, modeling of, 243–44
- preferences and behavioral response metrics, 250–51
- risk preferences, 245
- risk principles and enterprise risk management, 239–40
- variability and randomness, 251–52
- Vining and Boardman choice problem, **246**
- riskmeter, 55
- robust optimization, 100–101
- robustness, 205
  - in adversary decision making, 577–80
  - to execution and observation uncertainty, 579–80
  - optimal defensive resource allocations and, 689–94
  - PASAQ solution concept vs defender strategy, 644, 645
  - in Stackelberg security game, 579
- rocket-propelled grenades (RPGs), 450
- second-order probability distributions, 99–100
- security applications, deployed and emerging, 490–91, **491**
- security games, 3
  - applications, 499–500
  - basic, 509–10
  - best response in, 509
  - example of a very simple, 510
  - green, 488–89, 496–98
  - infrastructure, 488, 491–96
  - opportunistic crime, 489–90, 498–99
  - research issues, 500–503
    - bounded rationality, 502
    - integrating dynamic information, 503
    - planning and learning, 502
    - robustness, 501
    - scalability, 500–501
  - with scheduling constraints, 526–35
  - with uncertainty, 519–26
- separation oracle, 607
- severity index for terrorist consequences, 369–71, **370**
- simulations for decision-making processes
  - experimental setup, 591–92
  - general population as an approximation for threats, 590–91
  - result analysis, 592–98, **594, 597–98**
- slave problem, 531–32
- smallpox vaccination policy, 469–74, 724
  - mass vaccination, 474–80
  - pre-*vs* post-attack vaccination, 480–82, 481
  - ring vaccination *vs* mass vaccination, 474–77
- society equity, 682
- Society for Decision Professionals' (SDP) mission, 336–37
- SOFTMAX function, 583
- Southern California Planning Model (SCPM), 220
- Soviet Union, 115
- SPARS, 527–33
- Stackelberg equilibrium, 510
- Stackelberg Security Games (SSG), 26, 538
  - applying regret minimization techniques to repeated, 621–22
  - basics, 486–87
  - Bayesian, 519–21
  - compact, 512–19
  - defender's mixed strategy, 512
  - formal definition, 510–12
  - heuristic methods to solve large, 564–70
  - learning to play
    - Monte Carlo Tree Search (MCTS), 612–16
    - multi-armed bandit problem, 620
    - optimization with membership queries, 607–9
    - sequence of attackers, 616–22
    - single attacker drawn from a distribution, 610–16
    - single unknown attacker, 604–7
    - trade-off of exploration and exploitation, 610
    - using membership queries, 609–10
  - mixed-integer programming formulations of, 541–47
  - payoff table, **487**
  - payoffs for an attack on a target, 513, **513**
  - robustness in, 579
  - solving, 512
- Standardized Industry Code system, 223
- static economic resilience, 202, 204–5
- static resilience, 171, 202

- statistical variations, 85
- strategic and non-strategic threats, literature on, 680–83
  - equity or fairness, in terms of, 682–83
- Strategic National Stockpile (SNS), 135
- Strong Stackelberg Equilibrium, 629
- subjective judgments, 15, 85
- Subjective Utility Quantal Response (SUQR) model, 585, 622
- substitution effect, 458
- substitution rule, 409–10
- success trees, 17–18
- support theory, 581
- surviving population, 177
- sustainable hazard mitigation, 201
- swing weight assessment procedure, 721, **722**
- systematic errors, 85
- systems dynamic (SD) models, 22–23
  
- Tactical-Strategic Stack (TSS), 69–72, **70**
- terrorism insurance
  - challenges in, 259–63
    - dynamic uncertainty and time scale, 260–62, 262
    - example of fire insurance, 260
    - potential for catastrophic losses, 262–63
  - decision processes of insurers regarding, 263–66
  - insurer behavior
    - Chicago's O'Hare Airport, case of insuring, 265–66
    - impact of availability bias on, 265–66
    - likelihood and consequences of, 264
    - Oklahoma City bombing of 1995, case of insuring, 265
- terrorism risk, quantifying, 8–11, 465
  - tools for, 11–27
  - uncertainties in, 86–90
- terrorism risk assessment models (TRAMs), 55, 80
  - authors' experience, **58**
  - capturing risk-generating process
    - alternative probabilistic causal chains, 62–63
    - initiation process, 61
    - scenario-shaping process, 61–62
    - unanticipated scenarios, 62
  - model quality perspectives, 63–64
    - data and assumptions, 63
    - framed within the context, 64
    - scope boundaries, 64
  - in risk management decision-making process, 64–68
  - subject matter expert (SME) judgments, 59–60
  - for terrorist-defender game, 69–73
  - understanding application of
    - alternative probabilistic causal chains, 75
    - assumptions, 75
    - best feasible jobs, 76
    - capabilities, 77
    - incorporation of uncertainties into risk management decisions, 76
    - initiation process, 74
    - problem of defender uncertainty, 77–78
    - scenario-shaping process, 74
    - scope boundaries between BTRA and DMP, 76–77
    - unanticipated scenarios, capture and account for, 74–75
  - understanding of usefulness of 13 tests, 73–78
  - validation conceptual framework, 59–61
- Terrorism Risk Insurance Act (TRIA) of 2002, 259, 266–73
  - after 2014, 270
  - Direct Earned Premium (DEP), 266
  - eligible lines of business, 266–67
  - estimating losses from terrorist attack scenarios, 269–73
  - loss sharing arrangement, 268, 268–69, **271**
  - mandatory offer requirement, 266
  - structure of, 266–69
- terrorist objectives
  - of Al Qaeda, 383–91
    - relationships between fundamental and strategic objectives, 382
  - hierarchies, 381–83
  - identifying, 377–79, **378, 380**
  - of ISIL, 383–91
  - structuring, 380–81
  - understanding, 376–77
- terrorist threat, 445
- terrorist-defender game, 69–73
  - consistent set of intelligence and skills, 72
  - problem of defender uncertainty, 73
  - Tactical-Strategic Stack (TSS), 69–72, **70**
- terrorists, 111–15
  - attractive terrorist targets, 115
- THIRA process, 33
- Threat and Hazard Identification and Risk Assessment (THIRA), 50

- time-path of resilience, 205–7, 206
- tools for terrorism risk analysis, 11–27
- Bayesian networks, 24–25
  - causal loop diagrams, 22–23
  - decision trees, 11, 14, 14–16, 404, 452–65, 453, **454–56**, 462–64, 476, 478
  - event trees, 11, 13–14, 17
  - game theoretic models, 25–27
  - influence diagrams, 18–21
  - logic trees, 12–18
  - systems dynamic models, 22–23
- Total Dynamic Economic Resilience (TDER), 209
- Total Static Economic Resilience (TSER), 207–9
- interdependencies affecting resilience, 208
  - magnitude of DSER and, 208
  - off-site considerations, 208
- Transportation Security Administration (TSA), 503
- truck transportation costs, 301, **302**
- See also* U.S. Customs and Border Protection (CBP)
- TRUSTS for Urban Security in Transit Systems, 486, 494, 494–95, 631
- responses against threats (FE, CT, and CR), 631
  - schedules, 660–63
- uncertainties, 85
- about consequences of possible attacks, 87–88
  - about one's own values (present and future), 89–90
  - in adversarial risk analysis, 102–5
  - defender, 88–89
  - making prudent decisions in, 105
  - role in terrorism risk analysis, 86–90
  - strategies to deal with statistical and deep, 90–102
  - Bayesian posterior distribution for timing of an attack, 91, 92–93
  - computational methods for detecting changes and quantifying, 90–94, 91–93
  - likelihood-based methods, 91, 91–92, 93–94
  - predicting adversarial risks, 94–105
  - surveillance methods, 91–92, 92
- unmanned aerial systems (UAS), 3, 428
- Archimedean utility copula, control strategies using, 435–38
  - attributes and individual goal functions for, 432–35
  - collision avoidance, 433–34
  - experiments using, 438–42, 439–42
  - proximity objectives, 434–35
  - surveillance, 433
  - utility of multiple objectives with, 432–35
- upper confidence bound (UCB), 614
- Upper Confidence Bounds for Trees (UCT) algorithm, 614
- U.S. Customs and Border Protection (CBP)
- enforcement missions, study of changes in transportation costs for trucks, 301
  - truck operating costs, 299–300
  - truck opportunity cost of time savings, 301, **302**
  - truck travel distances, 298–99
  - volumes of truck traffic at the border, 295–98, **296–97**
  - wait times for trucks at the border, 298
- computable general equilibrium (CGE) analysis of macroeconomic impacts, 308–9
- conclusions and possibilities for future research, 316–17
- economic impact analysis of CBP
- inspection staffing changes, 307, 309–10, 312–14, **313**, 317n2, 319n26
- economic impacts of changes, 283–85, **286**
- expenditure changes
- of air travelers, 310–12, **311**
  - of land travelers, 309–10
- macroeconomic analysis, 281–83, 303–5
- changes in tourism and business travel, 305–14
- methodological overview, 278–85, 279
- microeconomic analysis, 279–81, 285–95
- average wait time changes, **292–93**
  - cross-border trips and wait time, 290–94
  - international air arrivals at airports, 294–95
  - value of time saved for existing traffic, 287–90
  - wait time of adding an officer, impact of, 285–87, **288–89**
- officers, 277
- at San Ysidro border crossing, 312, 319n25, 320n27
- study limitations, 314–16, **315**
- U.S. land freight port of entry and changes in U.S. GDP, **306**

774

*Index*

- U.S. Federal Air Marshal Service (FAMS), 485
- U.S. Special Operations Command Central (SOCCENT), 387
- utility copulas for attribute dominance utility functions, 422
- utility payoff matrices, 629
- utility theory, 1
- validation, 56–57, 81
  - defining, 57
- value model, 332, 345–46, **587**, 679, 711
  - construction of, 346–50
    - combining the achievement on different objectives, 349
    - identifying objectives, 347–48
    - specifying metrics to measure objectives, 348–49
  - value trade-offs, 349
  - proxy multiple objectives, 711–12, 727
- value trade-offs, 349
  - assessment of, 360–66
- Value-Focused Thinking: A Path to Creative Decisionmaking* (Keeney), 377
- vehicle routing model, 136, 148–51
  - constraints defined, 150–51
  - example, 151–54, 152, 154
  - mathematical expression for, 149
- vehicle routing problem (VRP), 147
- Vendor-Managed Inventories (VMI), 135
- vertical equity, 682
- Virginia Department of Emergency Management (VDEM), 338
- Virginia Homeland Security Grant Program (HSGP), 2009–present, 338–41, 339
- vulnerable near-miss events, 748
- warning systems, 746–47
- waterborne incendiary explosive device (WBIED), 649
- weapons of mass destruction (WMDs), 54, 72
- weight and rate choice
  - criterion, 405–9
- weight-and-rate scoring function, 406
- World Economic Forum Global Risks Report, 33