

Subject Index

Note: References to the four supplemental chapters are shown as Supplement A, Supplement B, Supplement C, and Supplement D.

A

ABC classification. *See also* Inventory management

- continuous review system and, 428
- example, 428–429
- lead time and, 428
- periodic counting and, 430
- two-bin system and, 428

ABC classification system, periodic review system, 428

ABS function, Supplement A

Absolute references, Supplement A

Acceptable quality level (AQL), 199, 227

Acceptance sampling. *See also* Statistical quality control (SQC)

- average outgoing quality, 201–203, 215
- defined, 175, 197
- goal of, 198
- operating characteristic (OC) curves, 199–200
- sampling plans, 198–199

Accounting

- aggregate planning and, 487
- inventory management and, 452
- JIT and lean systems and, 245
- project management and, 598
- resource planning and, 526
- scheduling and, 562
- supply chain management and, 131
- total quality management (TQM) and, 166
- work system design and, 404

Act, in PDSA cycle, 153

Action bucket, 521, Supplement D

Action notices, 521

Activity-on-node (AON), 580

Advertising revenue model, 102

Affiliate revenue model, 102

Aggregate planning

- across the organization, 486–487
- back orders, 471
- business planning and, 468–470
- capacity-based options, 471
- current situation evaluation, 473–474
- demand-based options, 471–472
- duration of the change, 474
- finished goods inventory, 471
- hiring and firing, 473
- magnitude of the change, 474
- within OM, 486–487
- options, 471–474
- options summary, 473
- overtime, 472
- pandemic effects on, 486
- point of departure, 473–474
- shifting demand, 472
- strategies, 475–476
- subcontracting, 472
- supply chain link, 487
- sustainability link, 487
- undertime, 472
- yield management and, 485

Aggregate plans

- chase, 476, 480–481, 484–485

for companies with nontangible products, 481–485

for companies with tangible products, 478–481

defined, 469

development of, 476–486

with hiring and firing, 480–481, 484–485

hybrid, 476, 483–484

identifying, 477

implementation, 486–487

with initial workforce and overtime, 483–484

with inventories and back orders, 478–480

level, 475–476, 482–483

with no back orders, no tangible product, 482–483

performance evaluation, 479–480

steps in, 477, 478

testing, 479

Aggregate production rate, 479

AGVs (automated guided vehicles), 75

ALDEP (automated layout design program), 351

Algebraic approach, Supplement A

Algebraic formulation, Supplement B

Allowance factor, 394, 398, 406, 410

Alternative workplace

- considerations, 386
- defined, 385
- desk sharing, 385–386
- hoteling, 385, 386
- telework center, 385
- teleworking and telecommuting, 385
- virtual office/virtual workplace, 385, 386

AMT (Asset Management Tool), 505

Answer Report, Solver, Supplement B

Anticipation inventory, 419, 420

AON (activity-on-node), 580

Application service provider (ASP), 506

Appointments, 558–559

Appraisal costs, 145

AQL (acceptable quality level), 199, 227

Arrival rate, Supplement C

AS/RSs (automated storage and retrieval systems), 75

Assemble-to-order strategy, 65

Asset Management Tool (AMT), 505

Assignable causes of variation, 176

Assigning tasks to workstations, 360

Atmosphere, 145

ATP. *See* Available-to-promise

Attributes

- control charts for, 180–181, 186–187
- defined, 180

Authorized MPS, 511, 512

Automated guided vehicles (AGVs), 75

Automated layout design program (ALDEP), 351

Automated order entry systems, 101

Automated storage and retrieval systems (AS/RSs), 75

Automation

- advantages and disadvantages of, 74
- defined, 74

flexible manufacturing system (FMS), 75

material handling, 74–75

numerically controlled (NC) machines, 75

robotics, 75–76

Available-to-promise (ATP). *See also* Master production schedule (MPS)

defined, Supplement D

quantities, Supplement D

quantity calculation formulas, Supplement D

records, Supplement D

revised records, Supplement D

row, Supplement D

AVERAGE function, Supplement A

Average number of jobs in the system, 549–550, 569

Average outgoing quality (AOQ)

- curve, 201–202
- defined, 201
- equation, 201, 216

Average transportation inventory (ATI), 460

B

B2B. *See* Business-to-business

B2C. *See* Business-to-consumer

Backlogs, 559

Back-ordering, 426

Back orders

- aggregate plan with, 482–483
- defined, 471

Backward integration, 114

Backward scheduling

- defined, 510, 545
- illustrated, 544

Balance delay, 360

Balking, Supplement C

Base-case spreadsheet model, Supplement A

Basic partnerships, 117

Batch processes, 62

Behavioral feasibility, 381–382

Benchmarking

- in continuous improvement, 153
- defined, 54, 153

Best operating level, 307

Beta probability distribution, 585, 591

Bills of material (BOM)

- components, 514–515
- defined, 510, 514
- end item, 515
- indented, 514
- parent item, 515
- product structure tree, 514–515

Binding constraints, Supplement B

Black belts, Six Sigma, 145

Black box diagram, Supplement A

Block plans

- ALDEP and, 351
- CRAFT and, 351
- with decision-support tools, 351
- developing, 351
- load-distance model and, 349
- with trial and error, 349–350

BOM (bill of material), 510

- Bottlenecks, 542
 - defined, 65
 - elevating, 558
 - exploiting, 558
 - identifying, 558
 - scheduling, 555–557
 - system inventory and, 556
 - throughput determination and, 556
 - time needed by, 542
- Bottom-round management, 238
- Break-even analysis. *See also* Location analysis
 - defined, 55, 324
 - equations, 324
 - fixed costs and, 55
 - graphical approach, 56
 - quantity computation, 57
 - steps in, 324
 - using, 325–327
 - variable costs and, 55–56
- Break-even point, modeling, Supplement A
- Break-even quantity, 56–57
- Broad view of the organization, 223
- Bullwhip effect
 - causes of, 99–100
 - counteracting, 100
 - defined, 99
- Business functions
 - information flow between operations and, 20
 - organizational chart, 2
- Business planning
 - hierarchy, 469
 - master production schedule, 470
 - sales and operations planning, 468–469
 - strategic business plan, 468
- Business process reengineering, 13
- Business results, in MBNQA, 163
- Business strategy
 - core competencies, 31
 - defined, 27
 - developing, 29–30
 - environmental scanning, 29–31
 - formulation of, 30–31
 - inputs in developing, 32
 - mission, 29–30
 - relationship with operations strategies, 27
 - understanding role of, 32
- Business-to-business (B2B)
 - defined, 16
 - e-commerce, 101–103
 - transactions, 94
- Business-to-consumer (B2C)
 - defined, 16
 - e-commerce, 101–103
- C**
- C2C (customer-to-customer), 16
- CAD (computer-aided design), 76–77
- CAE (computer-aided engineering), 76
- CAM (computer-aided manufacturing), 76
- Capacity
 - alternatives, developing, 310–311
 - alternatives, evaluating, 311
 - available, calculating, 534
 - competitors and, 311
 - considerations, 307–310
 - defined, 304
 - demonstrated, Supplement D
 - design, 306
 - diseconomies of scale and, 308–309
 - economies of scale and, 307
 - effective, 306
 - effectiveness of use, 307
 - focused factories and, 309
 - forecasting, 310
 - measure examples, 306–307
 - measuring, 306–307
 - purchase of, 305
 - requirements, identifying, 310–311
 - subcontractor networks and, 309–310
- Capacity-based options. *See also* Aggregate
 - planning
 - defined, 471
 - hiring and firing, 473
 - overtime, 472
 - subcontracting, 472
 - undertime, 472
- Capacity-constrained resources, 556
- Capacity cushions, 311
- Capacity planning
 - across the organization, 328
 - decisions, 304–306
 - defined, 304
 - importance of, 304–305
 - issues, 304–305
 - within OM, 328
 - rough-cut, 523–524, Supplement D
 - steps in decisions, 310–311
 - supply chain link, 329
 - sustainability link, 329
- Capacity planning using overall planning
 - factors (CPOPF)
 - defined, 523, Supplement D
 - example, Supplement D
 - planning factors, Supplement D
 - procedure for, Supplement D
- Capacity requirements planning (CRP),
 - 523–525. *See also* Resource planning
 - data from MPS, 523
 - defined, 510
 - open shop orders and, 523
- Capacity utilization
 - computing, 307
 - defined, 307
 - formula, 307, 335
- Capital costs, 425
- Causal models. *See also* Forecasting models
 - defined, 259
 - linear regression, 274–277
 - multiple regression, 277–278
- Cause-and-effect diagrams, 154
- c-charts
 - constructing, 190–191
 - control limits, 191, 215
 - defined, 187
 - use of, 186–187
- Cell layouts, defined, 345
- Cells
 - layouts of. *See also* Group technology (cell)
 - layouts
 - manufacturing, 234–235
- Center of gravity approach, 317
- Champion, Six Sigma, 197
- Chance events, 312
- Changing Cells, Solver, Supplement B
- Chase aggregate plan. *See also* Aggregate plans
 - advantage of, 476
 - defined, 476
 - using hiring and firing, 480–481, 484–485
- Checklists, 155
- CIM (computer-integrated manufacturing), 77
- Closed-loop MRP, 509
- Collaborative Planning, Forecasting and Replenishment (CPFR)
 - defined, 284
 - implementation of, 284
 - as iterative process, 285
 - nine-step process, 284
 - premise, 284–285
- Collaborative product commerce (CPC)
 - software, 77
- Combining forecasting, 284
- Common causes of variation, 176
- Community considerations, in location
 - decisions, 316
- Compensation
 - gain sharing, 403
 - group incentive plans, 402–403
 - incentive plan trends, 403
 - output-based (incentive) systems, 402
 - overview of, 402
 - profit sharing, 402–403
 - time-based systems, 402
- Competitive advantage, technology as tool,
 - 38–39
- Competitive evaluation, 157
- Competitiveness, productivity and, 41–42
- Competitive priorities
 - cost, 33–34
 - defined, 33
 - flexibility, 35
 - intermittent operations and, 69
 - operations and, 69
 - order winners and order qualifiers and, 36
 - quality, 34
 - time, 34–35
 - trade-offs, 35–36
 - translating into production requirements,
 - 36–37
- Competitors
 - capacity and, 310
 - ideas from, 54
- Completion dates
 - beta probability distribution, 591
 - probability calculation, 591–593
 - probability estimation, 591–593
 - variance of activities calculation, 591–593
- Completion time estimation. *See also* Project
 - management
 - deterministic time estimates, 582–585
 - overview of, 582
 - probabilistic time estimates, 585–590
- Compliance metric, SCM, 129
- Components, defined, 418, 515
- Computer age, 12
- Computer-aided design (CAD), 76–77
- Computer-aided engineering (CAE), 76
- Computer-aided manufacturing (CAM), 76
- Computer-integrated manufacturing (CIM), 77
- Computerized relative allocation of facilities
 - technique (CRAFT), 351
- Concurrent engineering
 - computerized technologies and, 60
 - defined, 59
 - illustrated, 60
 - sequential design versus, 60
- Conformance, 144
 - costs of nonconformance, 151

- Conformance specification, 143
 - Constrained optimization problem, Supplement B
 - Constraints
 - binding, Supplement B
 - defined, Supplement B
 - equality, Supplement B
 - greater-than-or-equal-to, Supplement B
 - less-than-or-equal-to, Supplement B
 - market, 557
 - nonbinding, Supplement B
 - nonnegativity, Supplement B
 - policy, 557
 - shadow price, Supplement B
 - slack, Supplement B
 - Solver, Supplement B
 - Consumer expectations, e-commerce and, 103–104
 - Consumer's risk, 199–200
 - Continuous improvement
 - benchmarking, 153
 - defined, 152
 - kaizen, 152
 - plan-do-study-act (PDSA) cycle, 152–153
 - Continuous processes, 62, 63
 - Continuous review systems (CRS), 428, 451
 - Contracting metric, SCM, 129
 - Control charts
 - for attributes, 180–181, 186–187
 - c-charts, 187
 - center line, 179–180
 - defined, 154, 178
 - lower control limit, 179
 - mean and range together, 186–187
 - mean ($\bar{x}$ -bar) charts, 180–181
 - p-charts, 187
 - as quality tool, 154–155
 - range (R) charts, 184–185
 - types of, 180–181
 - upper control limit, 179
 - for variables, 180–184
 - Controllable inputs, Supplement A
 - Control limits
 - c-charts, 189, 216
 - p-charts, 187, 216
 - range (R) charts, 184–185, 215
 - $\bar{x}$ -bar charts, 181–184, 215–216
 - Copyright infringement, 107
 - Core competencies. *See also* Business strategy
 - defined, 31
 - leveraging, 119
 - organizational, 31
 - Correct model, Supplement A
 - Correlation coefficient, 277, 295
 - Cost-efficient operations, 422–423
 - Costs
 - appraisal, 145
 - capital, 425
 - as competitive priority, 34–35
 - of ERP systems, 508–509
 - external failure, 146
 - fixed, 55
 - holding, 425, 426, 434–435
 - internal failure, 145–146
 - inventory, 425–427
 - inventory policy, 434–435
 - item, 425
 - ordering, 426
 - prevention, 145
 - risk, 425
 - setup, 226, 446–447
 - shortage, 426
 - storage, 425
 - variable, 55
 - COUNT function, Supplement A
 - Courtesy/friendliness, 145
 - CPFR. *See* Collaborative Planning, Forecasting, and Replenishment
 - CPM. *See* Critical path method
 - CPOPF. *See* Capacity planning using overall planning factors
 - CR (critical ratio), 547
 - Cradle to Cradle, 167
 - CRAFT (computerized relative allocation of facilities technique), 351
 - Crashing projects, 594–596
 - cost estimates, 594, 595
 - critical activities, 596–597
 - defined, 594
 - diagram, 594
 - example, 595
 - Critical chain approach
 - adding safety time, 596
 - defined, 596
 - project buffer, 597
 - wasting safety time, 596–597
 - Critical path method (CPM)
 - defined, 579
 - network diagram, 580–581
 - Critical paths, 582, 597
 - Critical ratio (CR), 547
 - Crosby, Philip B., 148–150
 - Crossdocking
 - defined, 123
 - distributor, 123
 - failure, 124–125
 - implementation, 124–125
 - innovations, 124
 - manufacturing, 123
 - retail, 123
 - transportation, 123
 - types of, 123–124
 - Cross-functional decision making, 17
 - CRP. *See* Capacity requirements planning
 - CRS (continuous review systems), 451
 - Cultures, globalization and, 317
 - Customer and market focus, in MBNQA, 163
 - Customer-defined quality, 165
 - Customer population, waiting lines, Supplement C
 - Customer relationship management (CRM), 17
 - Customers
 - arrival rate, Supplement C
 - average number waiting, Supplement C
 - average time spent waiting, Supplement C
 - external, 153
 - focus on, 151
 - ideas from, 152
 - internal, 153
 - proximity to, 315
 - requirements of, 157
 - in service design, 81
 - service experience by, 77
 - services and contact with, 77–78
 - Customer service
 - defined, 421
 - inventory management for, 421–422
 - Customer-to-customer (C2C), 16
 - Cycle counting, 431
 - Cycles, 260
 - Cycle stock, 419
 - Cycle time
 - defined, 357
 - equation, 358
 - formula, 370
 - maximum output relationship, 358
 - maximum versus minimum, 359
 - reductions, 244
 - in units per day, 358–359
 - in units per hour, 358
 - volume production and, 357
- D**
- Data Tables. *See also* Excel; Spreadsheet models
 - creating, Supplement A
 - defined, Supplement A
 - illustrated, Supplement A
 - problem-solving, Supplement A
 - results, graphing, Supplement A
 - using, Supplement A
 - Days of supply, 460
 - Decision alternatives, 305
 - Decision points, 305
 - Decisions
 - capacity planning, 310–311
 - example, 6–7
 - insourcing versus outsourcing, 114–115
 - location, 310–311, 314–316
 - in long-range plan support, 27
 - operations, 36
 - operations management (OM), 7–9
 - product design, 69–70
 - product mix, Supplement B
 - sourcing, 113–118
 - strategic, 8
 - tactical, 8
 - technology, 73
 - Decision trees
 - defined, 311
 - expected value (EV), 313–314
 - illustrated example, 313
 - procedure for drawing, 312
 - procedure for solving, 313
 - reading, 313
 - using, 312
 - Decision variables, Supplement A, Supplement B
 - Defects
 - cost of, 146
 - inspections and, 203–204
 - variation in production process and, 176
 - zero, 149–150
 - Delayed services, 559
 - Delphi method, 310
 - Demand
 - dependent, 511
 - independent, 510–511
 - peak, staffing for, 559
 - types of, 510–511
 - uncertainty, 448
 - Demand-based options. *See also* Aggregate planning
 - back orders, 471
 - defined, 471
 - finished goods inventory, 471
 - shifting demand, 472

Demand forecast updating, 99
 Demand management, Supplement D
 Demand time fences, Supplement D
 Deming, W. Edwards, 148
 Deming Prize, 148–149, 163
 Demonstrated capacity, Supplement D
 Dependent demand, 511
 Descriptive statistics. *See also* Statistical quality control (SQC)
 defined, 175
 distribution of data, 178
 mean, 177
 range and standard deviation, 177, 178
 use of, 177, 178
 Design capacity, 306
 Design for manufacture (DFM), 58
 guidelines, 58
 Design for the environment (DFE), 127
 Design of experiment, 150
 Desk sharing, 385–386
 Deterministic time estimates
 calculation example, 583–584
 defined, 582
 slack and, 584, 585
 table, 583
 Digital Millennium Copyright Act (DMCA), 107
 Diseconomies of scale, 308–309
 Distribution inventory, 419
 Distribution management, 97
 Distribution of data, 178
 Distribution warehouses
 defined, 122
 importance of, 122
 Distributor crossdocking, 123
 Division of labor, 11
 DMAIC (Define, Measure, Analyze, Improve, Control), 197
 Do, in PDSA cycle, 153
 Documented model, Supplement A
 Double sampling, 198
 Due dates, 544
 Duplication, partnering and, 119
 Durability, 144
 Duration of the change, 474

E

Earliest due date (EDD), 547
 Early supplier involvement (ESI), 55, 120
 E-commerce
 advertising revenue model, 102
 affiliate revenue model, 102
 B2B, 101–103
 B2C, 101–103
 competition resulting from, 103–104
 consumer expectations and, 103–104
 copyright infringement and, 107
 defined, 15, 101
 government regulation and, 107
 safety and welfare issues, 107
 sales revenue model, 102
 sales tax collection and, 107
 subscription revenue model, 102
 supply chains and, 100–103
 transaction fee model, 102
 Economic feasibility, 381
 Economic order quantity (EOQ) model. *See also* Order quantity determination
 annual costs formula, 434–435
 assumptions, 432–434

 calculating, 435
 defined, 432
 formula, 435, 461
 illustrated, 433
 inventory policy costs calculation, 434–435
 non-EOQ order quantity and, 435–436
 policy, 445
 quantity discounts and, 445
 Economic production quantity (EPQ) model.
 See also Order quantity determination
 calculating, 438–440
 calculating ratios, 438
 defined, 436
 example, 439
 factors, understanding, 446–447
 formula, 437, 461
 illustrated, 437
 maximum inventory level and, 437, 438
 perpetual inventory record, 439
 total cost formula, 437
 use of, 437
 Economic trends, 30
 Economies of scale, 307–308
 EDD (earliest due date), 547
 EDI (electronic data interchange), 100
 E-distributors, 102
 Effective capacity, 306
 Efficiency
 defined, 4
 metric, 67
 operational, 28
 in product layout, 355–356, 360
 server, waiting line, Supplement C
 Electronic commerce. *See* E-commerce
 Electronic data interchange (EDI), 100
 Electronic requests for quotes (ERFQs), 101
 Electronic storefronts, 101
 Elemental time database, 396
 Ellwood, Mark, 399
 E-manufacturing, 76–77
 Employee boredom, eliminating, 383–384
 Employees. *See also* Workforce
 on call, 559
 empowerment, 153–154
 floating, 559
 part-time, 560
 scheduling, 559–560
 seasonal, 559–560
 temporary, 559
 work environment, 237
 Employment, lifetime, 239
 End item, 515
 Energy Star certification, 167
 Engineering plan, 469
 Enterprise resource management, illustrated, 504
 Enterprise resource planning (ERP)
 application service provider (ASP) and, 506
 benefits of, 507–508
 common database, 504
 costs of, 508–509
 defined, 17, 503
 design and implementation of, 9
 evolution of systems, 505–507
 implementation, 505
 improvements from using, 509
 as information technology, 73
 modules, 504–505
 motivation for implementation, 507

 nonmanufacturer use of, 506–507
 SCM software and, 505
 service costs, 508
 supply chain intelligence (SCI) and, 505
 system evolution, 505–507
 system selection, 508
 use of, 507–508
 Enterprise software, 508
 Environmental scanning. *See also* Business strategy
 defined, 29
 information from, 29
 trends and, 29–30
 EOQ. *See* Economic order quantity (EOQ) model
 E-purchasing
 benefits for suppliers, 112
 benefits to buyers, 112
 defined, 102, 111
 example web site, 113
 key features of, 112
 process, 111–112
 sourcing strategy, 111
 Equality constraint, Supplement B
 ERFQs (electronic requests for quotes), 101
 ERP. *See* Enterprise resource planning
 ESI (early supplier involvement), 55, 120
 Ethics, supplier management, 120–122
 Excel
 ABS function, Supplement A
 AVERAGE function, Supplement A
 COUNT function, Supplement A
 Data Table, Supplement A
 editing formulas in, Supplement A
 Footer dialog box, Supplement A
 formulas, Supplement A
 Goal Seek dialog box, Supplement A
 IF function, Supplement A
 INDEX function, Supplement A
 MATCH function, Supplement A
 MAX function, Supplement A
 MIN function, Supplement A
 NORM.S.DIST function, Supplement A
 NORM.S.INV function, Supplement A
 Options dialog box, Supplement A
 Page Setup dialog box, Supplement A
 Solver, Supplement B
 SQRT function, Supplement A
 Stacked Column chart, Supplement A
 STDEV function, Supplement A
 SUM function, Supplement A
 SUMPRODUCT function, Supplement A
 Exchanges, 103
 Executive opinion, 257
 Expanded partnerships, 117
 Expected value (EV), 313–314
 Expediting orders, 521
 Explosion process, 517
 Exponential smoothing, 265–266, 294
 External customers, 153
 External distributors
 defined, 95
 for manufacturers, 95
 service organizations, 97–98
 External factory, 240
 External failure costs, 162
 External setups, 233
 External suppliers, 95
 Extranets, 102

F

Facilities

- best operating level, 307
- location analysis, 314–328

Facility layout, 341–356

- across the organization, 363–364
- for intermittent *versus* repetitive operations, 71
- intermittent operations and, 69
- just-in-time manufacturing, 234–235
- layout planning and, 342
- layout types and, 343–346
- within OM, 363
- operations and, 69
- repetitive operations and, 69–70
- supply chain link, 364
- sustainability link, 364

Factor rating, 318–320

FCFS (first come, first served), 547

Feigenbaum, Armand V., 148, 149

Finance

- capacity planning and, 328
- defined, 43
- facility layout and, 364
- forecasting and, 286
- JIT and lean systems and, 245
- location analysis and, 328
- operations information flow and, 19
- operations strategy and, 43
- process selection and, 82–84
- product design and, 82–84
- in product screening, 55–57
- supply chain management (SCM) and, 131
- total quality management (TQM) and, 166

Financial metric, SCM, 129

Financial plan, 469

Finished goods, 419

Finished goods inventory, 471

Finite customer population, Supplement C

Finite loading, 543–544

Firing employees, 473, 474

First come, first served (FCFS), 547

Fitness for use, 144

Fixed costs, 55

Fixed-order quantity, 432

Fixed-position layouts, 346

Flexibility

- as competitive priority, 34–35
- defined, 13, 35, 224
- mass customization, 14
- product, 35
- resource, 233
- volume, 35

Flexible layouts, defined, 355

Flexible manufacturing system (FMS), 75

Flexible model, Supplement A

Floating employees, 559

Flowcharts, 154

Flow operations

- defined, 542
- routings, 542

Fluctuation inventory, 419, 420

Focused factories, 309

Forecast accuracy

- in forecasting model selection, 281
- for groups/families of items, 294
- mean absolute deviation (MAD) and, 278–279
- mean squared error (MSE) and, 278–279

measuring, 279–280

monitoring, 255

for shorter time horizons, 254

tracking signal, 280–281

Forecast bias, 280

Forecast error, 278, 295

Forecasting

- across the organization, 286
- capacity, 310–311
- combining, 284
- cost of, 283
- CPFR and, 284–285
- defined, 254
- guidelines for selecting software, 282–283
- importance of, 254
- level or variation, 259–274
- models, 254, 255
- within OM, 286
- predictive analytics and, 283–284
- principles of, 254
- process, 255–256
- qualitative methods, 256–259
- quantitative methods, 256–258
- specialty forecasting packages, 282
- spreadsheets, 282
- statistical packages, 282
- supply chain link, 286
- sustainability link, 287
- types of methods, 256–259

Forecasting models

- available data and, 281
- causal, 259
- data patterns and, 282
- exponential smoothing and, 265–266
- features of, 254
- forecast accuracy requirement and, 281–282
- forecast horizon and, 282
- linear regression, 274–277
- linear trend line, 269–271
- list of, 258
- multiple regression, 277–278
- naïve, 261
- selecting and testing, 255
- selection of, 281–282
- simple mean or average, 261
- simple moving average (SMA), 262
- time series, 258–259
- trend-adjusted exponential smoothing, 268–269
- weighted moving average, 265–266

Forecasts

- content decision, 255
- data analysis and evaluation, 255
- generation of, 254–255
- horizon length, 282

Formulation. *See also* Optimization

- complete, Supplement B
- constraints and, Supplement B
- defined, Supplement B
- examining, Supplement B
- feasible solution, Supplement B
- infeasible solution, Supplement B
- optimal solution, Supplement B

Forward integration, 114

Forward scheduling

- defined, 544
- illustrated, 544

Frequency of occurrence, 393–394

From-to-matrix, 371

G

Gain sharing, 403

Gantt charts

- defined, 543
- earliest-start, 588–590
- latest-start, 589
- load chart, 543
- progress chart, 543

General warehouses, 122

Globalization

- advantages of, 317
- border security and, 105
- defined, 316
- disadvantages of, 317
- location decisions and, 318–319
- supply chain management (SCM) and, 104–105

Global marketplace, 15

Global Organic Textile Standards (GOTS), 167

Global positioning systems (GPS), 73–74

Global priority rules, 547

Goal Seek approach, Supplement A

Goods and services consistency, 34

GOTS (Global Organic Textile Standards), 167

Government regulations, e-commerce and, 107

GPS (global positioning systems), 73–74

Greater-than-or-equal-to constraint, Supplement B

Green belts, Six Sigma, 197

Green operations, 15

Green Seal certification, 167

Green supply chain management, 107–109

Gross requirements, 512

Group technology (cell) layouts. *See also* Facility layout; Layouts

- advantages of, 362

- defined, 345

- parts organized by families, 362

- process flows, 362–363

H

Hawthorne effect, 12

Hawthorne studies, 12

Hedge inventory, 419

High customer attention approach, 81

High-performance design, 34

High-volume operations, scheduling, 542

Hiring and firing

- as capacity-based option, 473
- chase aggregate plan with, 480–481, 484–485
- defined, 473

Histograms, 156

Historical development

- computer age, 12
- concepts, 10
- electronic commerce, 15–16
- flexibility, 13
- global marketplace, 15
- human relations movement, 12
- Industrial Revolution, 11
- just-in-time (JIT), 13
- management science, 12
- milestones, 10
- outsourcing, 16–17
- overview, 9–10
- reengineering, 13
- scientific management, 11
- supply chain management (SCM), 14–15
- sustainability and green operations, 15

time-based competition, 14
 total quality management (TQM), 13
 Holding costs, 425, 426, 434–435
 Hot desking, 385–386
 House of quality, 157–159
 Human relations movement, 12
 Human resource managers, 20
 Human resources
 facility layout and, 363–364
 forecasting and, 286
 in MBNQA, 163
 process selection and, 82–84
 product design and, 82–84
 statistical quality control (SQC) and, 206
 total quality management (TQM) and, 167
 work system design and, 404
 Hybrid aggregate plan, 476, 483–484
 Hybrid layouts, 345

I

Idea development, 53–55
 Idle time, 360
 IF function, Supplement A
 Immediate predecessor, 356
 Incentives
 gain sharing, 403
 group plans, 402–403
 output-based system, 402
 plan trends, 403
 profit sharing, 402–403
 Incoming inspection, 111
 Indented BOM, 514
 Independent demand, 510–511
 INDEX function, Supplement A
 Industrial Revolution, 11
 Industry consortia, 103
 Infeasible problem, Supplement B
 Infinite customer population, Supplement C
 Infinite loading, 543, 544
 Information and analysis, in MBNQA, 163
 Information flow
 between operations and other business functions, 20
 organizational chart, 19
 supply chains, 96
 Information systems (IS)
 aggregate planning and, 487
 defined, 20
 forecasting and, 286
 inventory management and, 452–453
 JIT and lean systems and, 246
 process selection and, 82–84
 product design and, 82–84
 project management and, 599
 resource planning and, 526
 scheduling and, 563
 statistical quality control (SQC) and, 206–207
 supply chain management (SCM) and, 131
 total quality management (TQM) and, 167
 work system design and, 404
 Information technology (IT). *See also* Software
 defined, 38, 73
 ERP, 73
 examples of, 38
 GPS, 73–74
 rapid growth of, 255
 RFID, 74
 wireless technologies, 73–74
 Infrastructure
 issues, 106–107
 operations decisions, 37
 Input/output control, 545
 Inputs, Supplement A
 Insourcing
 decisions, 114–115
 defined, 113
 formula for, 138
 Inspections
 costs, 203
 frequency, 203
 location, 204
 tool selection for, 204
 Institute for Supply Management (ISM*), 121
 Interchangeable parts, 11
 Intermittent operations
 competitive priorities and, 69
 defined, 61
 facility layout and, 70–71
 repetitive operations versus, 61–62
 Intermittent processing systems, 333
 Internal customers, 153
 Internal failure costs, 145–146
 Internal functions, 95
 Internal operations, 97–98
 Internal resource constraints, 557
 Internal setups, 233
 Internet, government regulation of, 107
 Intimacy, partnering and, 119–120
 Intranets, 102
 Inventory
 aggregate decisions, 452
 anticipation, 419, 420
 back orders and, 426
 capital costs, 425
 costs, 425–427
 distribution, 419
 finished goods, 471
 fluctuation, 419, 420
 functions of, 420
 holding costs, 425, 426, 434–435
 item costs, 425
 in just-in-time manufacturing, 225
 lost sales and, 426
 lot-size, 419, 420
 maintenance, repair, and operating (MRO), 419–420
 manufacturer use of, 419–420
 minimum investment, 423–424
 ordering costs, 426
 policy costs, 434–435
 principles, 418–421
 risk costs, 425
 in service organizations, 420–421
 setup cost, 446–447
 speculative, 419, 420
 storage costs, 425
 target level, 449–450
 transportation, 419, 420
 types of, 418–419, 420
 Inventory management, 417–453
 ABC classification, 427
 across the organization, 452–453
 continuous review system, 428
 for cost-efficient operations, 422–423
 for customer service, 421–422
 cycle counting, 431
 days of supply, 424
 hours of supply, 424

idle time due to material and component shortages, 422
 lead time, 428
 minimum inventory investment and, 423–424
 objectives, 421–424
 within OM, 452–453
 order quantity determination, 431–432
 pandemic effects on, 452
 percentage of dollar volume shipped on schedule, 422
 percentage of line items shipped on schedule, 422
 percentage of orders shipped on schedule, 422
 periodic counting, 430
 periodic review system, 428, 449–452
 record accuracy, 430–431
 safety stock levels, 447–449
 supply chain link, 453
 sustainability link, 453
 two-bin system, 428
 vendor-managed inventory (VMI), 431
 weeks of supply, 423, 424
 Inventory records
 material requirements planning (MRP) and, 512–513
 planned orders and, 513
 planning factors, 513
 scheduled receipts and, 513
 Inventory turnover
 calculation, 460
 defined, 423
 IS. *See* Information systems
 Ishikawa, Kaoru, 148, 150
 ISM* (Institute for Supply Management), 121
 ISO 9000 standards, 163–164, 167
 ISO 14000 standards, 164, 167
 ISO 26000 standards, 164, 167
 Item costs, 425

J

Jidoka, 236
 JIT. *See* Just-in-time
 Job design
 alternative workplace, 385
 behavioral feasibility, 381–382
 defined, 381
 economic feasibility, 381
 employee boredom and, 383–384
 job enlargement and, 383–384
 job enrichment and, 384
 job rotation and, 384
 machines versus people, 382
 methods analysis, 387–389
 problem-solving teams, 384
 self-directed teams, 384–385
 specialization, 382–383
 special-purpose teams, 384
 team approaches to, 384–385
 technical feasibility, 381
 work environment, 386–387
 Job enlargement, 12, 383–384
 Job enrichment, 12, 384
 Job flow time, 548, 569
 Job lateness, 549–550
 Job rotation, 384
 Jobs
 priority, 546–547
 sequencing through two work centers, 553–555

Job tardiness, 550
 Jockeying, Supplement C
 Johnson's rule, 553
 Juran, Joseph M., 148–149
 Just-in-time (JIT)

across the organization, 245–246
 benefits of, 241–242
 broad view of, 222
 broad view of operations, 223
 champion for implementation, 242
 continuous improvement, 224
 cross-functional worker skills, 238–239
 cycle time reductions, 244
 defined, 13
 defining beliefs of, 223
 elements of, 225–228
 flexibility, 224
 implementing, 242–243
 JIT system, 225
 just-in-time manufacturing, 225, 228–234
 layout changes implementation, 243
 lifetime employment, 239
 lot size and lead time reduction and, 243
 management role, 238–239
 multifunction workers, 244
 within OM, 245
 philosophy, 222
 problem elimination, 223
 production employees, 238–239
 pull production implementation, 243
 quality improvements and, 243, 245
 respect for people, 227–228, 237–241
 in services, 243–244
 setup time reduction and, 243
 setup times and parallel processing, 245
 simplicity, 223–224
 supplier relationships, 240–241, 243
 supply chain link, 246
 sustainability link, 246
 total quality management (TQM), 226, 235–237
 uniform facility loading, 244
 visibility, 224–225
 waste elimination, 222–223
 workplace organization and, 245
 workplace reorganization and, 243
 Just-in-time manufacturing
 cell manufacturing, 234–235
 defined, 225
 external setups, 233
 facility layout, 234–235
 internal setups, 233
 inventory and, 225
 kanban, 225
 kanban production, 229–231
 master production schedule, 225
 multifunction workers, 234
 pull system, 225, 228–229
 resource flexibility, 233–234
 small-lot production, 232–233
 uniform plant loading, 233
 variations on kanban production, 230–231

K

Kaizen, 152, 224
 Kanban(s)
 cards, 229–231
 computing number of, 230
 defined, 225

formula, 230, 250
 production, 229–231
 signal, 231
 supplier, 231
 variations on production, 231–224

L

Labor sources, proximity to, 315
 Language barriers, 318
 Larger-scale waiting line systems, Supplement C
 Last come, first served (LCFS), 547
 Layout planning, 333–337
 Layouts. *See also* Facility layout
 fixed-position, 346
 flexible, 355
 group technology (cell), 345, 362–363
 hybrid, 345
 office, 355–356
 process, 343–344, 346–347
 product, 344–345, 355–356
 warehouse, 352–354
 LCFS (last come, first served), 547
 Leadership, in MBNQA, 162–163
 Lead time
 in ABC classification, 428
 cumulative, calculating, 516
 defined, 428, 513
 Lean systems. *See also* Just-in-time (JIT)
 across the organization, 245–246
 defined, 17
 within OM, 245
 Learning curves
 coefficients, 400–401
 formula, 400
 illustrated, 400
 importance of, 399–402
 theory, 399–402
 LEED certification, 167
 Less-than-or-equal-to constraint, Supplement B

Level aggregate plan, 475–476, 482–483
 Leveling, 233
 Leveraging
 core competencies, 119
 supply chain management strategies, 127–128
 LHS value, Supplement B
 Lifetime employment, 239
 Limits Report, Solver, Supplement B
 Linear program (LP) problems
 defined, Supplement B
 infeasible solution, Supplement B
 outcomes of, Supplement B
 Simplex Method, Supplement B
 unbounded, Supplement B

Linear regression. *See also* Causal models
 correlation coefficient, 277
 defined, 274
 fit to historical data, 274
 forecasting with, 275–276
 formula, 295
 least-squares straight line, 275
 relationship between variables, 275
 steps, 274–275
 Linear trend line. *See also* Time series models
 defined, 269
 equation, 269, 295
 forecasting with, 270–271

steps in process, 270
 Line processes, 62
 Line shape, 361
 Load charts, 543
 Load-distance model. *See also* Location analysis

in block plan development, 349–350
 calculation, 320
 defined, 320
 distance identification, 321
 load identification, 321
 rectilinear distance and, 321
 using, 321–323

Loading

finite, 543–544
 infinite, 543, 544
 uniform facility, 244
 uniform plant, 233–234
 Local priority rule, 546–547

Location analysis

across the organization, 328
 break-even analysis, 324–325
 center of gravity approach, 324
 defined, 304, 314
 evaluation procedures, 318–328
 facility location and, 328–329
 factor rating, 318–320
 factors affecting decisions, 315–316
 globalization and, 316–318
 load-distance model, 320–323
 within OM, 328
 supply chain link, 329
 sustainability link, 329
 transportation method, 325

Location decisions

community considerations, 316
 factors affecting, 315–316
 globalization and, 316–318
 procedure for making, 318
 proximity to customers and, 315
 proximity to source of labor and, 316
 proximity to sources of supply and, 315
 quality of life issues, 316
 site considerations, 316

Logistics, 97

Longest processing time (LPT), 547

Long-range plan, 27

Lost sales, 426

Lot-for-lot, 432

Lot-size inventory, 419, 420

Low-volume operations, scheduling, 542–543

LP. *See* Linear program (LP) problems

M

MAD. *See* Mean absolute deviation

Magnitude of the change, 474

Maintenance, repair, and operating (MRO)
 inventory, 419–420

Makespan, 548, 549

Make-to-order strategy, 65

Make-to-stock strategy, 65

Malcolm Baldrige National Quality Award
 (MBNQA), 162–163

Management, role in JIT, 238–239

Management science, 239–240

Managers, SQC implications for, 203–204

Manufacturability, 52

Manufacturers

ERP use, 505–506

external distributors, 95
 external suppliers, 95
 internal functions, 95
 postponement, 123
 quality in, 144–145
 supply chain components for, 95–96
 use of inventory, 419–420
 Manufacturing
 cell, 234–235
 just-in-time, 225, 228–235
 value-added, 225
 Manufacturing crossdocking, 123
 Manufacturing organizations
 characteristics of, 4–5
 defined, 4
 service organization differences, 4–6
 Manufacturing resource planning
 (MRP II), 509
 Marginal value, Supplement B
 Market constraints, 557
 Marketing
 aggregate planning and, 487
 concurrent engineering, 59–60
 customer expectations, 78
 defined, 43
 facility layout and, 364
 forecasting and, 286
 inventory management and, 452
 JIT and lean systems and, 245
 operations information flow and, 19
 operations strategy and, 43
 process selection and, 82–84
 product design and, 82–84
 in product screening, 58
 project management and, 598
 resource planning and, 526
 scheduling and, 563
 service design, 80
 statistical quality control (SQC) and, 206
 total quality management (TQM) and, 166
 work system design and, 404
 Marketing plan, 468
 Marketplace trends, 30
 Market research, 257
 Mass customization, 14
 Mass production, 12
 Master production schedule (MPS)
 available-to-promise (ATP) and,
 Supplement D
 as basis of communication, Supplement D
 defined, 225, 470, Supplement D
 demand management and, Supplement D
 developing, Supplement D
 evaluating and accepting, Supplement D
 extended record, Supplement D
 leveled, 225
 linkages, Supplement D
 as MRP input, Supplement D
 objectives, Supplement D
 within OM, Supplement D
 order promising and, Supplement D
 projected available quantity, Supplement D
 records, Supplement D
 stabilizing, Supplement D
 time fences and, Supplement D
 using, Supplement D
 Master scheduler
 defined, Supplement D
 MPS objectives, Supplement D

MATCH function, Supplement A
 Material requirements planning (MRP)
 systems. *See also* Resource planning
 action notices, 521
 authorized MPS, 511, 512
 backward scheduling, 510
 bill of material (BOM) and, 510, 514–515
 closed-loop, 509
 defined, 510, Supplement D
 example, 517–521
 expediting in, 521
 explosion process, 517
 functioning of, 517–523
 gross requirements, 512
 inventory records, 512–513
 lot size rules comparison, 521–523
 material resource planning (MRP II), 509
 MPS as input, Supplement D
 objectives of, 510
 operating logic of, 512–516
 overview illustration, 511
 overview of, 510
 reports, 526
 time-phased schedule, 511
 types of demand, 510–511
 use of, 12–13
 Material resource planning (MRP II), 509
 Materials requirements planning (MRP)
 systems, logic behind, 516
 Mathematical models, Supplement A
 MAX function, Supplement A
 Maximum cycle time, 359
 Maximum output, 358, 370
 MBNQA (Malcolm Baldrige National Quality
 Award), 162–163
 Mean, 177
 Mean absolute deviation (MAD)
 advantages of, 278–279
 defined, 278
 example use of, 279–280
 formula, 277, 295
 Mean flow time, calculating, 549
 Mean job flow time, 569
 Mean observed time, 392–393
 Mean squared error (MSE)
 advantages of, 278–279
 defined, 278
 example use of, 279–280
 formula, 277, 295
 Mental models, Supplement A
 Methods analysis. *See also* Job design
 defined, 387
 example, 387–389
 steps in, 387
 Methods-time measurement (MTM), 396, 397
 MIN function, Supplement A
 Mini-max system, 432
 Minimum cycle time
 maximum cycle time versus, 359
 maximum output and, 359
 Minimum inventory investment, 423–424
 Mission statement, 29
 Mixed-model line, 361
 Mixed services, 78
 Models. *See also* Spreadsheet models
 defined, Supplement A
 inputs/outputs, Supplement A
 types of, Supplement A
 Monitoring

forecast accuracy, 255
 project progression, 590
 workflow, 545–546
 Most likely time estimate, 585
 Moving assembly line, 12
 MRO (maintenance, repair, and operating)
 inventory, 419–420
 MRP. *See* Material requirements planning
 (MRP) systems
 MSE. *See* Mean squared error
 MTM (methods-time measurement),
 396, 397
 Multifactor productivity, 40
 Multifunction workers, 234, 244
 Multiple-criteria decision making
 absolute references in, Supplement A
 calculation, Supplement A
 formulas, entering, Supplement A
 illustrated, Supplement A
 input section, Supplement A
 relative references in, Supplement A
 spreadsheet modeling, Supplement A
 Multiple regression, 277–278
 Multiple-sampling plans, 198–199
 Multiplicative seasonality, 271
 Multiserver waiting line model. *See also*
 Waiting lines
 assumptions, Supplement C
 characteristics spreadsheet, Supplement C
 defined, Supplement C
 formulas, Supplement C
 probabilities of customers in the system,
 Supplement C
N
 Naïve method, 261–262, 295
 Net marketplaces, 101
 Network diagrams
 activity-on-node (AON), 580–581
 creating, 580–581
 critical path, 582
 early starts/early finishes network, 588
 example, 581–582
 late starts/late finishes network, 589
 network notation, 581
 precedence relationships, 579
 project activities, 579
 Nonbinding constraints, Supplement B
 Nonbottlenecks, 555, 556
 Nonnegativity constraints, Supplement B
 Nontangible products, aggregate plans for
 companies with, 481–485
 Normal times, 394, 410
 NORM.S.DIST function, Supplement A
 NORM.S.INV function, Supplement A
 Numerically controlled (NC) machines, 75
O
 Objective function, Supplement B
 Objectives, Supplement B
 Occupational Safety and Health Act (OSHA),
 387
 OC curves. *See* Operating characteristic (OC)
 curves
 Office landscaping, 355
 Office layouts. *See also* Process layouts
 characteristics of, 355
 flexible, 355
 office landscaping, 355
 proximity versus privacy, 355

- OM. *See* Operations management
 - On-time delivery, 34–35
 - Open shop orders, 523
 - Operating characteristic (OC) curves
 - acceptable quality level (AQL), 199
 - constructing, 201–202
 - consumer's risk, 199–200
 - defined, 199
 - developing, 200–201
 - with different steepness levels, 200
 - example, 199
 - lot tolerance percent defective (LTPD), 199
 - producer's risk, 200
 - Operational efficiency, 28
 - Operations
 - broad view of, 223
 - competitive priorities and, 70
 - cost-efficient, 422–423
 - degree of vertical integration and, 72–73
 - facility layout and, 69
 - function design, 33
 - intermittent, 61
 - internal, 97–98
 - product and service strategy and, 71–72
 - in product screening, 55
 - project management and, 599
 - repetitive, 61–62
 - scheduling and, 563
 - Operation sequencing, 546
 - Operations management (OM)
 - across the organization, 19–21
 - benefits of learning about, 2
 - decisions, 7–9
 - defined, 2
 - differences between manufacturing and service organizations and, 4–6
 - efficiency and, 4
 - historical development, 9–17
 - improper, 4
 - as management function, 2
 - operations strategy within, 43–44
 - in practice, 18–19
 - responsibilities, 6
 - role of, 3
 - success generation, 3
 - today's environment, 17–18
 - transformation process, 3
 - value added and, 4
 - Operations strategy
 - across the organization, 43–44
 - competitive priorities, 33–35
 - competitive priorities translation, 36–37
 - cost and, 33–34
 - defined, 28
 - design of operations function and, 33
 - developing, 33–37
 - flexibility and, 35
 - importance of, 28
 - need for tradeoffs, 35
 - within OM, 43–44
 - operational efficiency and, 28
 - operations decisions, 37
 - order winners and order qualifiers and, 36
 - quality and, 34
 - role of, 27–28
 - supply chain and, 44
 - sustainability and, 44
 - time and, 34
 - Opportunities
 - identification of, 30
 - partnering and, 119
 - Optimistic time estimate, 585
 - Optimization. *See also* Formulation
 - algebraic formulation, Supplement B
 - constrained problem, Supplement B
 - constraints, Supplement B
 - as decision support tool, Supplement B
 - decision variables, Supplement B
 - defined, Supplement B
 - feasible solution, Supplement B
 - infeasible solution, Supplement B
 - introduction to, Supplement B
 - LHS value, Supplement B
 - linear program (LP), Supplement B
 - objective, Supplement B
 - within OM, Supplement B
 - optimal solution, Supplement B
 - problem-solving steps, Supplement B
 - RHS value, Supplement B
 - solution interpretation, Supplement B
 - Solver basics, Supplement B
 - spreadsheet model development, Supplement B
 - use of, Supplement A
 - Optimized production technology
 - balancing the process and, 556
 - capacity-constrained resources and, 556
 - constraint consideration and, 557–558
 - defined, 555
 - nonbottleneck usage and, 556
 - principles, 556–557
 - process batch and, 557
 - resource usage and activation and, 556
 - scheduling bottlenecks and, 555–557
 - theory of constraints (TOC) and, 557–558
 - throughput and, 556
 - transfer batch and, 557
 - Order batching, 99
 - Order-cycle service level, 447
 - Ordering costs, 426
 - Order n periods, 432
 - Order promising, Supplement D
 - Order qualifiers, 36
 - Order quantity determination, 431–447
 - economic order quantity (EOQ), 432–436
 - economic production quantity (EPQ), 436–440
 - fixed-order quantity, 432
 - lot-for-lot, 432
 - mathematical models for, 432–443
 - mini-max system, 432
 - non-mathematical techniques, 431–432
 - optimal order quantity and, 445–446
 - order n periods, 432
 - quantity discount model, 440–443
 - single-period model, 443–445
 - smaller order quantities and, 445–446
 - stock-keeping units (SKUs) and, 431
 - Order winners, 36
 - Organizational chart
 - business functions, 2
 - flow of information, 19
 - Organizational core competencies, 31
 - Organizations
 - manufacturing, 4–6
 - quasi-manufacturing, 5
 - service, 4–6
 - OSHA (Occupational Safety and Health Act), 387
 - Outcomes, 312
 - Out of control, 179
 - Output-based (incentive) systems, 402
 - Output rate, 357
 - Outputs, Supplement A
 - Outsourcing
 - decisions, 114–115
 - defined, 16, 113
 - formula for, 138
 - U.S. market, 16
 - Overtime, 472, 483–484
- P**
- Paced lines, 361
 - Pandemic effects, 43
 - on aggregate planning, 486
 - on project management, 598
 - on resource planning, 525
 - on scheduling, 562
 - on work system design, 403
 - Parallel processing, 245
 - Parameters, Supplement A
 - Parent item, 515
 - Pareto analysis, 156
 - Pareto's law, 427
 - Partial cumulative binomial probability table, 201
 - Partial productivity, 39–40
 - Partnering
 - benefits of, 120
 - benefits possible from, 118
 - critical factors in, 118–119
 - defined, 117
 - duplication and, 119
 - evaluation, 118
 - impact and, 118–119
 - intimacy and, 118–119
 - leveraging core competencies and, 119
 - new opportunities and, 119
 - relationship characteristics, 120
 - types of, 121
 - vision and, 120
 - Part-time employees, 560
 - p -charts
 - constructing, 188–190
 - control limits, 187, 215
 - defined, 187
 - standard deviation, 187
 - use of, 186–187
 - Percentage of dollar volume shipped on schedule, 422
 - Percentage of line items shipped on schedule, 422
 - Percentage of orders shipped on schedule, 422
 - Performance measures
 - process, 67–68
 - scheduling, 548–550
 - SCM, 128–130
 - waiting line, Supplement C
 - Performance rating factor, 392–393
 - Periodic counting, 430
 - defined, 430
 - Periodic review system, 428
 - continuous review comparison, 451
 - defined, 449–450
 - example, 451

- target inventory level (*TI*) and, 449–450
- using, 451
- Period-order quantity (POQ), 521–523
- Perpetual inventory record, 439
- PERT. *See* Program evaluation and review technique
- Pessimistic time estimate, 585
- PFD allowance factor, 398
- Phases, waiting lines and, Supplement C
- Physical models, Supplement A
- Piece-rate incentives, 11
- Pipeline inventory. *See* Transportation inventory
- Plan-do-study-act (PDSA) cycle, 152–153
- Planned orders, 513
- Planning factors
 - defined, 513
 - formulas, Supplement D
- Planning time fences, Supplement D
- Plant-within-a-plant (PWP), 36
- Point of departure, 473–474
- Point-of-sale (POS) technology, 127
- Poka-yoke, 237
- Policy constraints, 557
- Political trends, 30
- POQ (period-order quantity), 521–523
- Posted schedules, 559
- Postponement, 123
- Precedence diagram, 356
- Precedence relationships, 579
- Predetermined time data, 396
- Predictive analytics, 283–284
- Prevention costs, 145
- Preventive maintenance, 237
- Price and availability, 111
- Price fluctuations, 100
- Priority rules
 - commonly used, 547
 - defined, 546
 - different, using, 551–553
 - global, 547
 - local, 546
 - steps for using, 547–548
 - use example, 547–548
 - waiting line, Supplement C
- Privacy, in office layouts, 355
- Probabilistic time estimates
 - advantage of using, 591
 - beta probability distribution, 585
 - defined, 582
 - earliest and latest start times calculation, 587–590
 - earliest-start Gantt chart, 588
 - expected times, 586–587, 601
 - late starts/late finishes network diagram, 589
 - latest-start Gantt chart, 589
 - most likely time estimate, 585
 - network diagram, 587
 - optimistic time estimate, 585
 - pessimistic time estimate, 585
 - table, 586
- Problem-solving teams, 384
- Process
 - continuum of process types, 62–63
 - designing processes, 64–66
- Process batch, 557
- Process capability
 - defined, 192
 - measuring, 192–196
- process variability and specification width
 - relationship, 193
- product specifications, 192
- Process capability index
 - computing, 192–193
 - defined, 192
 - formula, 192
 - in measuring process capability, 194
 - ranges, 193
 - values, 195–196
- Process flow analysis, 64
- Process flowcharts
 - assemble-to-order strategy, 65
 - customer flow, 66
 - defined, 64
 - elements of development, 64
 - make-to-order strategy, 65
 - make-to-stock strategy, 65
 - for product strategies, 65–66
- Process layouts. *See also* Facility layout; Layouts
 - block plan development, 348–349
 - challenge in, 343
 - characteristics of, 343, 344
 - closeness measures identification, 347–348
 - defined, 343
 - designing, 346–351
 - detailed, developing, 351
 - improper design of, 344
 - information gathering, 346–351
 - quality, 34
- Process performance metrics, 67–68
- Process velocity, 52–53
 - defined, 67
 - formula, 88
- Product design
 - defined, 53
 - final design, 57
 - goods versus services, 53
 - idea development, 53–55
 - within OM, 82–84
 - preliminary design and testing, 57
 - process, 53–55
 - process selection and, 68–71
 - product life cycle and, 59
 - product screening, 55
 - quality function deployment (QFD) and, 157–158
 - reliability and, 159–161
 - remanufacturing and, 60–61
 - service design, 53
 - simplification, 58
 - standardization, 58
 - steps in process, 54
 - sustainability, 84
 - total quality management (TQM) and, 157–159
- Product flexibility, 35
- Production card, 229
- Production employees, 238–239, 245
- Productivity, 39–43
 - competitiveness and, 41–42
 - computing, 40
 - defined, 39
 - example measures, 41
 - formula, 48
 - interpretation of measures, 41
 - measuring, 39–41
 - metric, 67
- multifactor, 40
- partial, 39–40
- service sector and, 42
- total, 39–40
- U.S. business sector, percentage change, 42
- Product layouts. *See also* Facility layout; Layouts
 - balance delay computation, 360
 - characteristics of, 345
 - cycle time, 357–358
 - defined, 344
 - efficiency, importance of, 346–347
 - efficiency computation, 360
 - idle time, 360
 - line balancing, 356
 - mixed-model line, 361
 - number of product models produced, 361
 - output rate, 357
 - paced lines, 361–362
 - precedence diagram, 356
 - shape of the line, 361
 - single-model line, 361
 - task assignment to workstations, 359
 - task identification, 356
 - theoretical minimum number of stations, 359
 - unpaced lines, 361
- Product life cycle
 - defined, 59
 - stages of, 59
- Product mix decision, Supplement B
- Product mixing, 123
- Products
 - characteristics of, 158
 - manufacturability, 52
- Product screening, 55
 - break-even analysis, 55–56
 - defined, 55
- Product specifications, 192
- Product structure tree
 - defined, 514
 - end item, 515
 - illustrated, 515
 - parent item, 515
 - paths through, 516
- Product technology, 38
- Profit sharing, 402–403
- Program evaluation and review technique (PERT)
 - defined, 579
 - network diagram, 580–581
- Progress charts, 543
- Project activities, 579
- Project buffer, 597
- Projected available
 - defined, 513
 - quantity calculation formula, Supplement D
- Project management, 577–599
 - across the organization, 598–599
 - completion date probability estimation, 591–593
 - completion time estimation, 582
 - completion time reduction, 593–596
 - concepts, 579–590
 - CPM and, 579
 - critical chain approach, 596–597
 - deterministic time estimates, 582–585
 - network diagram creation, 580–582
 - network planning, 579–580
 - within OM, 598–599

Project management (*Continued*)

- path identification, 583–584
- PERT and, 579–580
- probabilistic time estimates, 582, 585–590
- project description, 580
- project life cycle and, 577–579
- project progression monitoring, 590
- steps in, 580–590
- supply chain link, 599
- sustainability link, 599

Project processes, 62

Projects

- completion date probability, 591–593
- completion time, calculating, 582
- completion time, estimating, 582
- completion time reduction, 593–596
- crashing, 594–596
- critical path, 582
- defined, 578
- describing, 580
- life cycle, 577–578, 579
- progression monitoring, 590

Promptness, 145

Proximity, in office layouts, 308

Psychological criteria, 144

Pull systems

- defined, 225, 228
- push systems versus, 228
- with two kanban cards, 229

Purchase orders, 111

Purchasing

- defined, 110
- incoming inspection and, 111
- price and availability, 111
- purchase orders, 111
- requisition requests, 110–111
- in supply chain management, 110–113
- traditional process, 110–111
- traditional versus e-purchasing, 113

Pure services, 78

Push systems, 226

PWP (plant-within-a-plant), 36, 309

QQFD. *See* Quality function deployment

Qualitative forecasting methods

- characteristics of, 265
- defined, 256
- Delphi method, 258
- executive opinion, 257–258
- market research, 257
- strengths/weaknesses of, 256–257

Quality. *See also* Total quality management (TQM)

- atmosphere, 145
- awards and standards, 162–164
- competing on, 44
- as competitive priority, 34–35
- conformance, 144
- conformance specification and, 143
- cost of, 145–146
- courtesy/friendliness and, 145
- customer-defined, 165
- defect cost and, 146
- defining, 143–144
- durability and, 144
- fitness for use and, 144
- goods and services consistency and, 34
- gurus of, 147–151

high-performance design and, 34

house of, 157–159

manufacturing versus service organizations, 144–145

performance and, 144

process, 34–35

product design, 34

promptness and, 145

psychological criteria, 144

reliability and, 144

service, 204–205

Six Sigma, 196–197

supplier, managing, 161–162

support services and, 144

value for price paid and, 144

Quality at the source, 161, 227, 236–237

Quality circles, 150, 153, 238

Quality control

defined, 149

tools of, 154–157

total, 149

Quality Control Handbook (Juran), 149

Quality function deployment (QFD)

competitive evaluation, 157

customer requirements, 157–158

defined, 157

house of quality, 157–159

product characteristics, 158

in product design, 127

relationship matrix, 157

setting targets, 158

trade-off matrix, 158

Quality improvement, 149

Quality Is Free (Crosby), 150

Quality-of-life issues, in location decisions, 309

Quality planning, 149

Quality tools

cause-and-effect diagrams, 154

checklists, 155

control charts, 155–156

defined, 154

flowcharts, 154

histograms, 156–157

illustrated, 144

Pareto analysis, 156

scatter diagrams, 156

Quantitative forecasting methods

causal models, 259, 274–277

characteristics of, 256–257

defined, 256

list of, 258

strengths/weaknesses of, 256–257

time series models, 258–274

Quantity, break-even, 55–56

Quantity discount model. *See also* Order

quantity determination

annual costs formula, 440

defined, 440

example, 442

procedure, 441–443

procedure steps, 443

total cost curves, 442

total cost formula, 461

Quasi-manufacturing organizations, 5

Quasi-manufacturing services, 79

Queues, 546

Queuing system. *See also* Waiting lines
Supplement C**R**

Radio frequency identification (RFID)

applications, 125–126

defined, 74

requirement of use, 127

tags, 74

Range, 177

Range (*R*) charts. *See also* Control charts

center line, 184

constructing, 185

defined, 184

factors for 3-sigma control limits, 185–186

process shifts captured by, 186

with *x*-bar charts, 184–185

Rapid delivery, 35

Rationing and shortage gaming, 99

Raw materials

defined, 418

RCCP. *See* Rough-cut capacity planning

Rectilinear distance, 321, 349

Redundancy, product reliability with, 161

Reengineering, 13

Relationship matrix, 157

Relative references, Supplement A

REL chart, 349

Reliability

computing, 160–161

defined, 144, 159

formula, 171

with redundancy, 161

in TQM, 159–160

Remanufacturing, 60

Reneging, Supplement C

Reorder point, 447, 460

Repetitive operations

defined, 61

facility layout and, 69

intermittent operations versus, 61–62

organizational decisions for, 69

Repetitive processing systems, 333

Replenishment order quantity, 450, 451

Requisition requests, 110

Reservations, 559

Resource flexibility, 233–234

Resource planning, 503–527

across the organization, 525–526

enterprise resource planning (ERP), 503–509

material requirements planning (MRP), 510–523

within OM, 525–526

supply chain link, 526

sustainability link, 526–527

Respect for people. *See also* Just-in-time

manufacturing

defined, 227–228, 237

in JIT, 237–241

lifetime employment, 239

management role, 239–240

production employees, 238–239

supplier relationships, 240–241

Retail crossdocking, 123

Revenue formula, 88

Reverse engineering, 55

RFID. *See* Radio frequency identification

RHS value, Supplement B

Risk costs, 425

Robotics, 75–76

Robust design, 150

Role of operations management, 3

Rough-cut capacity planning (RCCP)
CPOPF, Supplement D
defined, 523, Supplement D
master scheduling and, Supplement D
within OM, Supplement D
Routings, 542

S

Safety stock
calculation of, 450, 461
defined, 419
demand uncertainty and, 448
example, 449
formula, 461
levels, determining, 447–449
order-cycle service level and, 447
reorder point, 447, 460
Safety time
adding, 596
problem, solving, 596–597
wasting, 596–597
Sales and operations planning, 468–469
Sales revenue model, 102
Sampling plans
defined, 198
double sampling, 198
multiple, 198–199
single sampling, 198
Scatter diagrams, 156
Scheduled receipts, 513
Schedules
constraint consideration in establishing, 557
posted, 559
slack, 545
time-phased, 511
workforce, 560–561
Scheduling, 540–563
across the organization, 562–563
appointments, 558–559
average number of jobs in the system and, 549
backward, 503, 510, 544, 545
bottlenecks, 555–557
concepts, 541–546
delayed services or backlogs, 559
employees, 559–560
forward, 544–545
Gantt charts, 543
high-volume operations, 542
job flow time and, 548
job lateness/tardiness and, 549, 550
makespan and, 548, 549
monitoring workflow and, 545–546
within OM, 562–563
optimized production technology and, 555–557
pandemic effects on, 562
performance measures, 548–550
posted schedules, 559
reservations, 559
schedule of operations development and, 546–555
for service organizations, 558–561
shop loading methods, 543–546
supply chain link, 563
sustainability link, 563
theory of constraints (TOC) and, 557–558
SCI. *See* Supply chain intelligence
Scientific management, 11–12

SCM. *See* Supply chain management
SCM software, 505
SCOR (Supply Chain Operations Reference)
model, 129–130
Scrap costs, 146
Seasonal employees, 559–560
Seasonal index, 271
Seasonal inventory, 419
Seasonality. *See also* Time series models
computation steps, 272–274
defined, 260
forecast example, 272–273
forecasting, 271–274
formula, 295
multiplicative, 271
Self-directed teams, 384–385
Sensitivity Report, Solver, Supplement B
Servers. *See also* Waiting lines
arrangement of, Supplement C
efficiency, Supplement C
in multiserver model, Supplement C
number of, Supplement C
in single-server model, Supplement C
Service design
customer involvement in, 81
defined, 53
differing, 80–82
high customer attention approach, 81–82
substituting technology for people, 80–81
Service organizations
appointments, 558–559
characteristics of, 5
defined, 4
delayed services or backlogs, 559
external distributors, 95, 96
internal operations, 97–98
inventory in, 420–421
manufacturing organization differences, 4–6
posted schedules, 559
productivity and, 42
quality in, 144–145
reservations, 559
scheduling employees in, 559–560
scheduling issues for, 558–561
scheduling techniques for, 558–559
staffing for peak demand, 559
supply chain for, 97–98
workforce schedules, 560–561
Service package, 79–80
Service rate, Supplement C
Services
classification of, 79
customer contact, 78–79
designing, 77–80
as intangible product, 77–78
JIT in, 243–244
manufacturing *versus*, 77–78
mixed, 78
pure, 78
quasi-manufacturing, 79
statistical quality control (SQC) in, 204–205
warehouse, 122
Service system, Supplement C
Setting targets, 158
Setup cost, 423, 446–447
defined, 226
Shadow price, Supplement B
Shewhart, Walter A., 148
Shifting demand, 472

Shortage costs, 426
Shortest processing time (SPT), 547, 548, 551–553
Signal kanban, 231–232
Simple mean or average, 261, 294
Simple moving average (SMA). *See also* Time series models
computing with, 265–266
defined, 265
forecasting with, 262–263
forecasting with (five-period MA), 264
formula, 262, 295
Simplex Method, Supplement B
Simplicity, defined, 223
Single-model line, 361
Single-period model. *See also* Order quantity determination
characteristics of, 443
defined, 443
example, 444–445
Single sampling, 198
Single-server waiting line model. *See also* Waiting lines
assumptions, Supplement C
characteristics spreadsheet, Supplement C
example, Supplement C
formulas, Supplement C
probabilities of customers in the system, Supplement C
Single setups, 233
Single-source suppliers, 240
Site considerations, in location decisions, 309
Six Sigma quality
black belts, 145, 197
champion, 197
defined, 196
DMAIC, 197
implementation aspects, 197
Skewed distribution, 178
SKUs (stock-keeping units), 421, 431
Slack
constraint, Supplement B
defined, 545, 584
finding, 584–585
Slack per remaining operations (S/RO), 547, 551–553
SMA. *See* Simple moving average
Small-lot production, 232–233
Social responsibility, 405
Social trends, 31
Software. *See also* Information technology (IT)
collaborative product commerce (CPC), 77
enterprise, 508
forecasting, 282–283
SCM, 505
Solver. *See also* Excel
Answer Report, Supplement B
basics, Supplement B
Changing Cells, Supplement B
constraints, Supplement B
defined, Supplement B
Limits Report, Supplement B
Sensitivity Report, Supplement B
setting up and running, Supplement B
solution reports, Supplement B
Solver Options, Supplement B
specifying model to, Supplement B
steps for using, Supplement B
Target Cell, Supplement B

- Sourcing decisions, 113–122
 - formula, 138
 - insourcing versus outsourcing, 114–115
 - number of suppliers and, 116–117
 - partnerships and, 117–120
 - supplier management ethics and, 120–122
 - supplier relationship development, 115
- Sourcing strategy, 111
- SPACECRAFT, 351
- SPC. *See* Statistical process control
- Specialization
 - advantages/disadvantages of, 383
 - defined, 382
 - in job design, 382–383
- Special-purpose teams, 384
- Specialty forecasting packages, 282
- Speculative inventory, 419, 420
- Spreadsheet models, Supplement A
 - algebraic approach, Supplement A
 - for analysis, Supplement A
 - assessing, Supplement A
 - base-case, Supplement A
 - column chart, Supplement A
 - constructing, Supplement A
 - correct model, Supplement A
 - Data Tables, Supplement A
 - defined, Supplement A
 - development steps, Supplement A
 - documented model, Supplement A
 - evaluating, Supplement A
 - Excel formulas, Supplement A
 - flexible model, Supplement A
 - formulas, entering, Supplement A
 - Goal Seek approach, Supplement A
 - illustrated, Supplement A
 - modeling process, Supplement A
 - multiple-criteria decision making, Supplement A
 - within OM, Supplement A
 - in optimization, Supplement B
 - results, graphing, Supplement A
 - stacked column chart, Supplement A
 - testing, Supplement B
 - tips, Supplement A
- Spreadsheets
 - formulas, Supplement A
- SPT (shortest processing time), 547, 548, 551–553
- SQC. *See* Statistical quality control
- SQRT function, Supplement A
- S/RO (slack per remaining operations), 547, 551–553
- Standard deviation, 178
- Standards development
 - allowance factor, 394
 - elemental time base, 396
 - frequency of occurrence, 393–394
 - mean observed time, 392–393
 - normal time, 392–393, 410
 - number of observations, 391–392
 - performance rating factor, 392–393
 - predetermined time data, 396
 - time study, 391–392
- Standard time
 - benefits of, 389–390
 - calculating, 395
 - in costing products, 389–390
 - defined, 389
 - formula, 410
 - use of, 389–390
- State of control, 179
- Statistical packages, 282
- Statistical process control (SPC). *See also* Control charts
 - attributes, 180, 186–187
 - defined, 215
 - methods, 178–179
 - out of control, 179
 - state of control, 179
 - variables, 180–186
- Statistical quality control (SQC)
 - acceptance sampling, 175, 197–203
 - across the organization, 206–207
 - categories of, 175
 - defined, 175
 - descriptive statistics, 175–176
 - implementation of, 207
 - implications for managers, 203–204
 - within OM, 206–207
 - process capability, 192–196
 - in services, 204–205
 - Six Sigma quality, 196–197
 - statistical process control (SPC), 175, 178–191
 - supply chain link, 207
 - sustainability link, 207
- STDEV function, Supplement A
- Stock-keeping units (SKUs), 421, 431
- Stopwatch time studies, 11
- Storage areas. *See also* Warehouse layouts; Warehouses
 - of equal sizes, 352
 - of unequal sizes, 353
- Storage costs, 425
- Strategic alliances, 30–31
- Strategic business plan, 468
- Strategic decisions
 - defined, 8
 - tactical decisions relationship, 8–9
- Strategic planning, in MBNQA, 163
- Structure, operations decisions, 37
- Study, in PDCA cycle, 153
- Subcontracting, 472
- Subcontractor networks, 302–303
- Subscription revenue model, 102
- Substituting technology for people approach, 80–81
- SUM function, Supplement A
- SUMPRODUCT function, Supplement A
- Supplier kanbans, 231
- Suppliers
 - e-purchasing benefits, 112
 - external, 95
 - ideas from, 54–55
 - in JIT, 240–241
 - management ethics, 120–121
 - number of, 116–117
 - one versus multiple, 116
 - opportunities for, 114
 - purchase price and availability and, 111
 - quality, managing, 161
 - relationships, developing, 115
 - single-source, 240
 - tier one, 96
 - tier three, 96
 - tier two, 96
- Supply chain carbon footprint analysis, 108
- Supply chain intelligence (SCI), 505
- Supply chain link, supply chain management (SCM) and, 131
 - across the organization, 131
 - compliance metric, 129
 - contracting metric, 129
 - defined, 14, 94
 - e-commerce and, 101–103
 - financial metric, 129
 - globalization and, 104–105
 - government regulation and, 107
 - green, 107–109
 - implementing, 126–127
 - infrastructure issues and, 106–107
 - issues affecting, 100–103
 - leveraging strategies, 127–128
 - for manufacturers, 95–96
 - within OM, 130
 - overview, 14–15
 - performance metrics, 128–130
 - purchasing and, 111–112
 - software, 505
 - sourcing decisions, 113–122
 - supply chain link, 131
 - warehouses and, 122–126
- Supply chain management, sustainability and, 132
- Supply Chain Operations Reference (SCOR) model, 129
- Supply chains
 - aggregate planning and, 487
 - basic, 94–100
 - bullwhip effect and, 99–100
 - capacity planning and, 328
 - dairy products, 95–96
 - defined, 14, 94
 - design trends, 106–107
 - e-commerce and, 101–103
 - forecasting and, 286
 - illustrated, 95
 - information flow, 99
 - inventory management and, 453
 - just-in-time (JIT) and, 246
 - location analysis and, 328
 - for manufacturers, 95–96
 - OM function and, 19
 - operations strategy and, 44
 - process selection and, 83–84
 - product design and, 83
 - project management and, 599
 - publishing, 14–15
 - resource planning and, 526
 - scheduling and, 563
 - for service organizations, 97–98
 - total quality management (TQM) and, 167
 - for travel agency, 98–99
 - work system design and, 404
- Supply chain velocity, 106
- Supply sources, proximity to, 315
- Support services, 144
- Sustainability
 - aggregate planning and, 487
 - capacity planning and, 329
 - defined, 15
 - facility layout and, 364
 - forecasting and, 287
 - inventory management and, 453
 - ISO standards for reporting, 164
 - just-in-time (JIT) and, 246
 - location analysis and, 329

metrics, 207
 OM function and, 21
 operations strategy and, 44
 product design and, 83
 project management and, 599
 resource planning and, 526–527
 scheduling, 563
 supply chain management (SCM) and, 132
 total quality management (TQM) and, 167
 work system design and, 405

System utilization rate, Supplement C

T

Tactical decisions
 defined, 8
 strategic decisions relationship, 8–9
 Taguchi, Genichi, 148, 150–151
 Taguchi loss function, 151
 Tangible products, aggregate plans for
 companies with, 478–481
 Target Cell, Solver, Supplement B
 Target inventory level (*TI*), 449–450, 460
 TBO (time between orders), 450
 Team approach, 153–154
 Teams
 problem-solving, 384
 self-directed, 384–385
 special-purpose, 384
 Technical feasibility, 381
 Technology
 automation, 74–76
 computer-aided design (CAD), 76–77
 computer-integrated manufacturing (CIM), 77
 decisions, 73–77
 e-manufacturing, 76–77
 information, 37–38, 73–74
 process, 38
 product, 38
 strategic role of, 37–39
 substitution for people, 80–81
 3D printing, 77
 as tool for competitive advantage, 38–39
 types of, 38
 wireless, 73–74
 Telecommuting, 385–386
 Teleworking, 385–386
 Temporary employees, 559
 Testing
 aggregate plans, 479
 forecasting models, 255
 in product design, 57
 spreadsheet models, Supplement B
 Theoretical minimum number of stations, 359
 Theory of constraints (TOC)
 constraint types and, 557–558
 defined, 557
 steps for using, 558
 Third-party service providers, 126
 Threats, identification of, 30
 3D printing, 77
 Throughput, 556
 Throughput time, 67
 Tier one suppliers, 96
 Tier three suppliers, 96
 Tier two suppliers, 96
 Time
 cycle, 244, 357–358, 370

idle, 360
 job flow, 548, 569
 lead, 404, 428, 513, 516
 mean observed, 392–393
 normal, 392–393, 410
 on-time delivery and, 35
 rapid delivery and, 35
 safety, 596–597
 shortest processing (SPT), 547, 548, 551–553
 standard, 391, 394, 395, 410
 throughput, 67
 wait, Supplement C
 Time-based competition
 defined, 14
 systems, 402
 Time between orders (TBO), 450
 TimeCorder, 399
 Time fences
 demand, Supplement D
 example, Supplement D
 illustrated, Supplement D
 planning, Supplement D
 policies, Supplement D
 Time measurement units (TMUs), 396–397
 Time-phased schedule, 511
 Time series, 258
 Time series models. *See also* Forecasting models
 cycles, 260
 defined, 259
 exponential smoothing, 265–266
 forecasting level or variation, 258–274
 level or horizontal pattern, 259–268
 linear trend line, 269–271
 naïve method, 261
 random variation, 260
 seasonality, 260, 271–274
 simple mean or average, 261
 simple moving average (SMA), 262–265
 trend-adjusted exponential smoothing, 268–269
 trends, 259, 268–271
 weighted moving average, 265–266
 Time study
 defined, 391
 normal times and, 392–393, 410
 number of observations and, 391–392, 395–396, 410
 procedure for, 391–392
 standard time and, 389–390, 395, 410
 TMUs (time measurement units), 396–397
 TOC. *See* Theory of constraints
 Tolerances, 192
 Total cost formula, 88
 Total item time, 534
 Total productivity, 39
 Total Quality Control (Feigenbaum), 149
 Total quality management (TQM). *See also* Quality
 across the organization, 166–167
 continuous improvement, 152–153
 customer focus, 151
 defined, 13, 143, 148, 162, 226
 employee empowerment, 153–154
 evolution of, 147–151, 162
 failure, causes of, 165
 gurus of, 148–151
 in JIT, 226, 235–237

within OM, 166
 philosophy of, 151
 preventive maintenance, 237
 process management, 161
 product design, 157–161
 product versus process, 235
 quality at the source, 227, 236–237
 quality function deployment (QFD) and, 157–161
 reliability and, 159–161
 supplier quality management, 161
 supply chain link, 167
 sustainability link, 167
 team approach, 153–154
 use of quality tools, 154–157
 work environment, 237
 Tracking signal, 280–281, 295
 Trade-off matrix, 158
 Trade-offs
 competitive priorities, 36–37
 defined, 35
 Traffic management, 97
 Transaction fee model, 102
 Transfer batch, 557
 Transportation consolidation, 122
 Transportation crossdocking, 123
 Transportation inventory, 419
 Transportation method, 325
 Trend-adjusted exponential smoothing, 268–269, 295
 Trends
 driving supply chain design, 106–107
 economic, 30
 forecasting, 268–271
 incentive plans, 403
 marketplace, 30
 political, 30
 seasonality, 271–274
 social, 31
 time series models, 259, 268–269
 Turnover, inventory, 423, 460
 Two-bin system, 428
 Types of inventory, 418–419, 420
 Types of waste, 223

U

Umtplus, 399
 Unbounded problem, Supplement B
 Uncontrollable inputs, Supplement A
 Undercapacity scheduling, 236
 Undertime, 472
 Uniform facility loading, 244
 Uniform plant loading, 233
 Units per day, output in, 358
 Units per hour, output in, 358
 U.S. employment by economic sector, 6
 Utilization
 defined, 67
 formula, 88

V

Value added, 4
 Value-added manufacturing, 225
 Value chain management (VCM), 102–103
 Value for price paid, 144
 Variable costs, 55–56
 Variables
 control charts for, 179–180
 defined, 180
 linear regression, 275

Variation

- assignable causes of, 176
- common causes of, 176
- product consistency and, 176–177

Vendor-managed inventory (VMI), 431

Vertical integration

- defined, 113
- operations and, 72–73
- as strategic decision, 72–73

Virtual office, 385

Virtual private networks (VPNs), 101

Visibility, 224

Vision, partnering and, 120–121

Visual models, Supplement A

VMI (vendor-managed inventory), 431

WWaiting lines. *See also* Multiserver waiting line model; Queuing systems; Servers; Single-server waiting line model

- arrangement of servers and, Supplement C
- arrival and service patterns, Supplement C
- arrival rate, Supplement C
- average number of customers waiting, Supplement C
- average time customers spend waiting, Supplement C
- cost and service level trade-off, Supplement C
- customer population, Supplement C
- defined, Supplement C
- elements of, Supplement C
- large-scale systems, Supplement C
- multiserver model, Supplement C
- number of, Supplement C

number of servers and, Supplement C

within OM, Supplement C

operational characteristics, changing,

Supplement C

performance measures, Supplement C

phases, Supplement C

priority rules, Supplement C

server efficiency, Supplement C

service facilities, Supplement C

service rate, Supplement C

service system, Supplement C

single-server model, Supplement C

system utilization rate, Supplement C

Wait time, Supplement C

Warehouse layouts. *See also* Process layouts

- characteristics of, 352
- storage areas of equal sizes, 352
- storage areas of unequal sizes, 353–354

Warehouses

- crossdocking, 123
- distribution, 122
- general, 122
- product mixing, 122
- radio frequency identification (RFID) and, 125–126
- role in SCM, 121–122
- services, 122
- supply chain link, 405
- sustainability link, 405
- third-party service providers, 126–127
- transportation consolidation, 126

Weeks of supply, 423, 424

Work environment, total quality management (TQM) and, 237

Workflow, monitoring, 545–546

Workforce. *See also* Employees

- schedules, developing, 560–561
- size, calculating, 479

Work-in-process (WIP)

- defined, 418–419
- inventory, 422

Workload calculation, 523–524

Work measurement, 389–402

defined, 389

work sampling, 397–399

Workplace, virtual, 385, 386

Work sampling, 397–399

Workstations, assigning tasks to, 359

Work system design

- within OM, 404–405
- social responsibility and, 405
- work measurement, 389–402

Xx-bar charts. *See also* Control charts

- constructing, 181–184
- control limits, 181–184, 215
- defined, 180
- factors for 3-sigma control limits, 185
- formulas, 181
- process shifts captured by, 186
- with range (*R*) charts, 184–185
- from sample range, 183

Y

Yield management, 485

Z

Zero defects, 149

z value, 592–593, 600

