THE DEFINITIVE GUIDE TO WAREHOUSING
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MANAGING THE STORAGE AND HANDLING OF MATERIALS AND PRODUCTS IN THE SUPPLY CHAIN

Council of Supply Chain Management Professionals
Scott B. Keller and Brian C. Keller
Dedicated to Karen C. Keller—Mother, friend, and family logistician.
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WAREHOUSING’S ROLE IN THE SUPPLY CHAIN

Introduction
This chapter explores warehousing’s expanded role in customer operations and supply chain management. You learn about historical and current examples of warehouse support to manufacturing, purchasing, and various economies of operations. This chapter discusses competitive supply chain strategies, providing examples of value-added services that warehouses can now provide. With the expansion from a one-dimensional storage repository to a main element of customer supply chains, the warehouse is now expected to contribute to the overall client business objectives and contribute to cost reductions.

Warehousing’s Role in the Supply Chain
Warehousing played a role in the storage and exchange of goods for centuries. Long-term storage to provide product for future consumption has been a utility of warehousing both past and present. Transit sheds, warehouses connected to a wharf, have facilitated the movement and storage of goods embarking or disembarking merchant and military vessels supplying domestic and world trade. Rail transportation set in motion the industrial era with the transport of agriculture commodities and livestock; warehousing was leveraged to store such cargo prior to processing and then distribute finished products traveling to other parts of North America.

Long-term storage and places to interchange products may have been enough utility prior to and during the initial stage of industrial development; however, U.S. involvement in World War II required the manufacturing of products to support military efforts. Increased manufacturing demanded more storage and organization of raw materials and parts, as well as more room for the stockpiling and strategic positioning of completed military products from ammunition and vehicles, to food stores. Figure 1-1 depicts a
high-cube military storage warehouse. Warehousing became more of a strategic function in the chain of supplying the U.S. military and its allies.

![High-cube military storage warehouse](image)

**Figure 1-1  High-cube military storage warehouse**

**Army Warehouses in World War II**

During World War II the U.S. Army established supply warehouses in the state of Washington. These depots played critical roles in supplying the war effort in the Pacific. The depots warehoused large quantities of material. The warehouses in Washington delivered goods through the ports to support the war in the Aleutian Islands. They also supported the war in the Pacific by shipping critical equipment and supplies to Hawaii and beyond.

Engineering breakthroughs partially resulting from war efforts were adopted by industry post WW II. Although railroads provided dominance in freight transport prior to the World War II, motor carriers and eventually air carriers would surface as viable competition for freight transportation. Competitive changes, such as these, changed the face of warehousing. Now, a warehouse could receive a single truckload of product rather than a railcar load of product. Dynamics of unloading a tractor-trailer load compared
to unloading a railcar are dramatically different and require differential planning for unloading and storage.

At the same time, developments were achieved in forklift handling equipment. Simple pallet jack capabilities were exceeded by higher reach forklifts enabling operators to build and manage freight in higher vertical storage buildings and reduce the fixed cost of engineering and fabricating the facility.

With the proliferation of computers, information exchange in the late 20th century became a game-changer in the way warehouses collected, transmitted, and utilized data and information within facilities and with warehouse customers. Perhaps computers came about in such good time to enable warehouse operators better control over the increasing variety of products demanded by consumers. Ever since the end of WW II, the United States realized a growing middle class society demanding a greater selection of products that required greater warehouse control. Product variations require greater skill in inventory control over that of managing a single commodity or a few finished goods items. Each unique product type requires a location in the warehouse that it cannot share with a different product type. Moreover, as market expansion spread, so too did the number of warehouses called upon to service the distant markets. Products to satisfy customer regions were dedicated to a specific market warehouse. Consequently, the aggregate inventory total for all market warehouses increased the investment in stock required to compete for market share.

Traditional Roles of Warehousing
Although supply chains demand greater service value from warehouse operations, the basic economies of manufacturing, purchasing, and transportation must continue to be supported. Cost trade-offs, along with service expectations, must be evaluated to determine the role of the warehouse in supporting the traditional economies of scale.

Supporting Functional Economies of Scale
Wide scope business strategies catering to broad-based clientele require large scale purchasing, production, and distribution. Achieving competitive scale demands operating efficiencies and economies supported by large scale warehousing of supplies and product. Economies of scale in purchasing, production, and transportation have long required warehouse support, and today, need continues for such warehouse support.

Role in Supporting Economies of Manufacturing
Long manufacturing runs of single products create efficiencies in production processes, allocation of personnel, and capacity utilization of machinery and equipment. A manufacturer and marketer of a major brand of candy found that it would be financially feasible to
operate a single production line for three flavors of a specific candy. To change from one product to another, the changeover process required that the machinery be completely disassembled, sterilized, and reassembled prior to running the next item on the master production schedule. Three days were required to complete the changeover, and the sterilization was critical because one of the three products included a nut ingredient. Sterilization reduced the threat of cross-contamination of products that could have devastating consequences if consumed by people with severe allergies toward nut products.

Plant supporting warehouses must add value in the supply chain by supporting long manufacturing runs to gain economies of production and reduce changeover needs. Single-item finished products produced in mass quantities must be stored and maintained for future demand.

**Role in Supporting Economies of Purchasing**

Materials planners utilize the master production schedule and materials requirements plans to determine ordering needs for each material or component required to meet production plans. Planners and procurement personnel work together to evaluate material needs, lead times for receiving materials, and price-break concessions afforded to buyers for ordering in bulk quantities. All the components influence the need to receive and store materials and components for future production. Specifically, bulk purchase pricing may provide cost-savings per item that when purchased in great enough quantity it more than offsets the cost of storing and maintaining the materials.

Warehouse operators add value for manufactures, assembly operations, and consolidation points by receiving, storing, maintaining, picking, and shipping materials and components to support large volume purchase discounts. The need is further realized as variations in quality and lead times necessitate purchasing added safety stock to protect against such fluctuations.

**Role in Supporting Economies of Transportation**

Similar to both manufacturing and purchasing economies, the better a carrier utilizes the full capacity and capability of its transportation equipment, the more efficient and cost-effective products are transported. Transportation cost per unit is reduced as a greater number of units are transported. Fixed costs are spread over the greater product amount being transported, and the variable costs do not necessarily increase one-for-one as another case of product is loaded onto a trailer and transported. Truckload (TL) business models are based on this premise, and truckload (LTL) and package carriers create bulk shipments by consolidating or bundling independent orders destined for a common ZIP code zone.

Costs associated with managing and holding greater levels of inventory in warehouse stock must be compared with the cost of transporting in large quantities to gain economies of transportation associated with reduced unit pricing. In many supply chains the
transportation savings per case or item more than offsets the cost to warehouse additional product. Carriers can more efficiently utilize transportation equipment and offer discounts to shippers for helping carriers fill trailers. Warehouses add value by supporting large volume transportation needs.

Demand for Contemporary Warehousing

Warehousing has been called upon by corporate to add value to supply chains while continuing to support traditional economies of scale and customer demand. As discussed, large storage warehouses are utilized to stockpile inventory that is produced, purchased, and transported in quantities large enough to gain competitive and cost-effective economies of manufacturing, procurement, and transportation. Such economies cannot be ignored by contemporary warehouse operators; however, additional factors must be considered when designing the strategy of the warehouse plan.

Anticipatory Inventory

Many times products are produced in anticipation of demand and especially items that have a low cost associated with each unit. Brands associated with long historical demand data and with relatively predictable patterns (little unexpected variations in customer ordering quantities) may be prime candidates for producing in anticipation of the forecasted demand. Items with well-established demand patterns, low cost of goods sold, and minimal handling requirements would be kept in stock at levels to meet ordering and service requirements of customers. Although all inventory represents value in terms of dollars, items such as canned vegetables that have relatively steady base demand patterns, strong historical demand data for adjusting forecasts based on other relevant factors, ordered in case and/or pallet quantities, and require little value-added within the warehouse are potential items for anticipatory inventory.

Seasonal Stocking

Red and white, and sometimes varied in colored, candy canes sold and consumed during the December holiday season represent an extreme case of seasonal stock. Manufacturers of the candy begin production and stock piling inventory well before orders are shipped to wholesalers and retailers. Historically, a southern U.S. candy maker would level production of the item by producing candy canes months in advance of demand so that labor and production machinery could more efficiently be utilized. Production strategies like this helped to reduce costs associated with overtime and running equipment near maximum capacity, thereby, risking an equipment breakdown. Producing well in advance of the season also allowed the candy maker to adjust production plans as the season approached. Compared to many other consumer products, candy canes are relatively low in cost per unit, require little handling without the cost of palletizing materials, may be
stacked in high-bay storage, and are less susceptible to theft. As such, warehouse costs are more than offset by the reduction in production and labor costs.

**Balances Supply with Demand**

It is infeasible to expect all customers to possess the capacity to order and receive full truckloads or even full pallet quantities of single items. Moreover, not all have the capability to store or the equipment to receive in large quantities, be it single items or mixed pallets. Warehouses offer storage to support production economies while also allowing customers the ability to order in lesser quantities and more often. Product assortment is available to customers so that they are not forced to receive and hold large quantities of single items in stock. In addition, warehouses receive products from various producers and offer a single point of interchange with the customer for distributing multiple items from multiple manufacturers. This minimizes the exchange points necessary between producers and their many customers.

**Protection Against Uncertainty in Demand and Lead Time**

As previously discussed, seasonality may be a factor in the increase of demand for products sold and consumed during holidays or other seasons. Short-term marketing and sales promotions designed to stimulate customer purchases also must be considered in determining future demand while changes in business cycles and product life cycle trends may influence longer-term demand patterns for some products. Various influences on demand must be identified and taken into consideration when planning production; otherwise, left unknown, the factors may create an uncertainty in the quantity and assortment ordered by customers. Manufacturers will have to rush special production and carriers will have to expedite shipments; all adding cost to the supply chain while risking the loss of sales due to a product shortage when customers demand.

Warehouse inventory is compiled in anticipation of forecasted future demand. In addition, safety stock includes inventory on-hand to protect against any unknown influences that stimulate demand beyond the level forecasted. Under such conditions, warehouses are utilized to position and maintain stock in strategic locations where uncertainty exists and forecast accuracy is low.

In a similar manner, carrier on-time transit and delivery may fluctuate due to unforeseen circumstances or in extreme cases on-going poor quality of on-time delivery service. Marketers wanting high levels of in-stock availability will, in this case, hold a level of safety stock above the forecast to meet demand even if carrier deliveries are delayed.

**Competitive Supply Chain Strategies**

Beyond supporting traditional economies of production, purchasing, and transportation, modern-day warehousing must assist in achieving corporate strategies designed
to compete based on low cost and differentiation through various time-based strategies. Michael Porter, Harvard Business School professor and leading expert on competitive business strategy, and others have long established these as two overarching corporate-level strategies.

**Low-Cost Strategy**

Low-cost corporate strategies may require long-term storage of large quantities of product. This was shown to support economies in production, purchasing, and transportation. Warehouses offer intermediate stocking points so that manufacturers do not have to service each individual final customer location. This allows manufacturers to ship in larger quantities to regional facilities servicing multiple end customers. The longest distance from the manufacturer to the regional warehouse utilizes truckload carrier service, thus leaving the shortest final distance for the more costly, yet flexible, LTL services. Overall, the total cost of transportation would be reduced with the help of the location of the regional warehouse (decentralized warehousing).

**Time-Based Strategies**

While walking through a warehouse, a customer service manager looked up and said, “Look at all that candy.” The accounting manager replied, “Look at all that money!” Twenty-first century supply chains must reduce costs and increase service to maintain competitiveness. Warehouses must do the same, and in ways unlike in the past break the service versus cost trade-off. By designing and adopting time-based strategies, supply chains may reduce inventory in the system and improve service responsiveness for themselves and their clients.

Firms are constantly seeking ways to reduce the lead-time from customer order placement to customer receipt of product and all while reducing levels of inventory in the system. Warehouses must contribute by instituting processes that are flexible and responsive to individual client needs. This may entail a cross-dock strategy, whereby, multiple shipments or items are received into the facility in bulk form and sorted according to final destination consignees. Orders for an individual consignee are then rebulked, loaded on an outbound trailer, and shipped to the destination without ever having been entered into storage.

Cross-docking and other time-based distribution strategies can assist in reducing supply chain system inventory, improving inventory turnover in stockaging warehouses, responding better to customer lead-time requirements, adjusting to demand fluctuations, and reducing distribution facility costs. Postponement is another product customization and distribution strategy used to support firm-level, time-based market strategies. Intermediate or final stages of product customization are postponed until actual demand is realized; at which point the product is finalized according to customer specifications. Items are
held in a higher level general state within materials or finished goods warehouse inventory until orders are received from customers.

**Interface Between Supply Chain Partners**

Warehouses occupy strategic positions between suppliers and customers. Oftentimes, warehouse operators are the last personnel to see and touch products before final delivery. As such, they are the final entity to inspect product quality, condition, and count, and verify documentation accuracy. During any time of receipt, putaway, storage, picking, or loading products are vulnerable to cost increases. It is the efficiency, accuracy, and overall customer orientation of the warehouse operator that ultimately influences final customer perception and reality of quality and cost.

Managers of warehouses and their employees, alike, must interface with clients and customers of clients. Therefore, warehouses must be seen and managed as supply chain partners. Their impact can mean the success or failure of supply chain relationships between marketers and the ultimate customers.

**Critical Customer Service Role of Warehousing**

For an order fulfillment center, customer service’s role in order processing encompasses receiving the completed order form via an electronic or a paper device. On-hand inventory is checked to verify that the amount of stock requested on the order is in the warehouse and available to fill that specific customer’s order. Stock availability, thereby, becomes a critical component of customer service that is influenced by the warehouse/order fulfillment center. Figure 1-2 illustrates warehouse racks consisting of multiple stock-keeping units with a majority of the slot locations having less-than-pallet quantities of product. Varied products and reduced inventory levels create challenges for warehouse operators to hold the correct amount of each product to satisfy customer demand.

When a stockout occurs and the item is not available in inventory when ordered, a customer must wait for the product to be replenished or authorize a substitute product to replace the original item ordered. Substituting a case of cherry breakfast pastries for a case of blueberry that was originally ordered may be of little consequence to the customer. (This is an assumption to make the point.) However, some products may not have suitable substitutes and a stockout could influence the customer to source from a competing supplier one time or for all future orders. Warehouses are often measured on stockout frequency or the related fill rate percentage of cases ordered (case fill rate = cases shipped / total cases ordered). This too impacts the ratio of orders shipped complete compared to total number of orders also known as order fill rate.
Frontline warehouse operations also influence the condition of the product upon shipping. Damaged product arriving at a customer’s facility may be denied and the bill of lading or delivery receipt adjusted at the receiving dock and the invoice cut or a claim initiated to recover the value of cases damaged. Percentage of damaged cases can be tracked over time to indicate severity and frequency of the problem. The number and type of a claim can be recorded and evaluated to identify potential issues and trends pertaining to specific items, customers, or warehouse order picking personnel.

Oversales, shortages, and damages (OS&D) cause issues that oftentimes adversely impact multiple partners within the supply chain. Take for instance an issue discovered by the customer service director for a warehouse that managed the southeastern U.S. product distribution for multiple manufacturers of major national household brands of consumable products. In an effort to improve the standing of the warehouse in the eyes of customers, the customer service director began conducting field visits to the receiving docks of customers. When walking into a small wholesaler, the director was greeted by an angry and frustrated owner. The owner showed the director a closet filled with empty boxes that he claimed arrived empty and concealed within the interior cases on pallets. The director and owner set out to discover the root cause of the concealed, empty cases. Assuming the pallets were full pallets of single items, it could be that the cases were empty when they were palletized at the end of the production line. A second possibility is that the cases were emptied by warehouse or carrier personnel anywhere along the distribution channel.
At the end of the supply chain, the wholesaler’s receiving personnel came in early mornings to break down pallets of product that were delivered during the night to a secured fenced area of the receiving dock. After careful investigation, it was determined that the wholesaler’s personnel were breaking down the pallets, emptying and taking the product out of some of the boxes, and then reconfiguring the cases on the pallets where the empty cases would be concealed among the full cases. The owner would come in an hour later to find the issue and naturally assumed the shipping warehouse or carrier was at fault.

Two more critical service factors influenced by warehouses include the lead time required to process and ship an order from the time the order is received and the consistency of that lead time. Greater lead-time requires added inventory in the system to fulfill orders during the time orders are processed. This refers to cycle stock. Moreover, as lead-times fluctuate additional units of inventory are necessary to satisfy customer demand during times when the lead-time increases. Safety stock is necessary to protect against such fluctuations in lead-times caused by inefficiencies in warehouse processes.

Today’s supply chains more often require flexible processes and partners. By working closely together to communicate alterations in demand and service needs, warehouse clients and operators can formulate the best circumstances for building flexibility in the warehousing and distribution system.

Light Manufacturing and Assembly
Partners subscribing to the supply chain concept continuously search for more efficient and economical means to reduce supply chain costs. Here is where warehouses can add value beyond tradition. For example, a third-party warehouse (neither the manufacturer nor the customer) was storing wiring harnesses for a major automobile assembly plant. A plant in Mexico’s Maquiladora region along the U.S. Texas border performed the laborious task of running and securing the many wires along each harness. To increase the value that the warehouse provided its customer, the warehouse operator drafted a proposal to perform the wiring of harnesses in the warehouse that is more strategically situated nearer the U.S. automotive assembly plant. The warehouse reduced the cost of the light manufacturing of the harnesses while also reducing the cost associated with the transportation and transit time required from the Mexican plant. Figure 1-3 illustrates a warehouse operation adding value by assembling tires to wheels that are then shipped just-in-time to the production line for final assembly on automobiles.

Oftentimes, certain light manufacturing or assembly activities can be more efficiently and effectively conducted within a warehouse instead of within a complex manufacturing plant. Under such circumstances, forward-thinking warehouse operators can add value in the supply chain by removing some of the manufacturing burden from the plant. This is especially beneficial given the warehouse has the capability to perform such processes to a level of expected quality and lead time all while reducing the cost to do so.
Summary of Key Points

Warehousing's role in the supply chain has become more critical and at an escalating rate during the past two decades. Responsibilities of warehouse operators have evolved from maintaining long-term storage of materials and products to supporting economies of purchasing, production, and transportation to including light manufacturing and facilitating time-based supply chain strategies.

Warehouse operations contribute to the overall total cost of managing a supply chain, and as such, the trade-offs between warehousing costs and services to that of other critical functions of the firm must be evaluated. It is when warehousing contributes to reduced costs and improved service, flexibility, and responsiveness that warehouses become more valued to the organization and supply chain as a whole.
Value is provided through

- Storing product to fulfill customer demand and protect against uncertainties in demand and lead-time
- Providing customers with product assortment
- Postponing or delaying inventory commitment to form or location until demand is better known
- Achieving low total cost and improved lead-time through consolidating multiple orders
- Reducing lead-time through cross-docking
- Sequencing materials and components from multiple third-party logistics (3PLs) providers for time-based delivery to factory production lines
- Performing light manufacturing, assembly, and kitting

Most important, warehouses impact the receiving customer in many critical ways. Front-line warehouse personnel may be the final customer service defense in ensuring product accuracy, quantity, timing of shipment and delivery, accuracy of documentation, and overall product condition—all of which impact total cost and customer perception of the brand.

Key Terms

- Anticipatory Inventory
- Bill of Lading
- Cost of Goods Sold
- Cross-Docking
- Cycle Stock
- Demand Patterns
- Distribution Channels
- Economies of Scale
- Fill Rate
- Fixed Cost
- Lead Time
- Less-Than-Truckload (LTL)
Chapter 1: Warehousing’s Role in the Supply Chain

- Mixed Pallets
- Overages/Shortages Damages (OS/D)
- Putaway
- Supply Chain
- Supply Chain Management
- Third-Party Logistics (3PL)
- Variable Cost

Suggested Readings


Index

Symbols

3PL (third-party logistics) providers, 16
4PL (fourth-party logistics) providers, 18

A

ABC analysis, 47
accessorial charges (freight rates), 127
accident prevention, 175
equipment safety devices, 177
safe product movement, 177-179
visual safety communication strategies, 176
accumulation, inventory, 16-17
accurate billing (performance measure), 108
active picking areas, 53, 94
advanced shipment notifications (ASNs), 198
affirmation, personnel, 69
A-frames, 48, 213
agreements (contracts)
key terms, 85-86
negotiations, 82
potential providers, 80-82
role of, 79

sections/content, 82
Services Agreement, 83-84
Terms and Conditions, 84-85
AGVs (Automated Guided Vehicles), 182, 212-213
AHP (analytical hierarchy processing), 200
Air Waybill, 140
aisles, considerations for warehouse design, 50
alarm systems, 190
allocation, inventory, 16-17
analytical hierarchy processing (AHP), 200
Anderson, Shelly, 72
anticipatory inventory, 5
Army warehouses, 2
ASNs (advanced shipment notifications), 198
AS/RS (Automated Storage and Retrieval Systems), 52, 211-212
assembly, warehouse value-added service, 10
assortment, inventory, 16-17
audio safety cues, 180-181
Automated Guided Vehicles (AGVs), 182, 212-213
automated handling systems, 92
automated palletizing machines, 114-115
Automated Storage and Retrieval Systems (AS/RS), 52, 211-212

B
barcode technology, 205-207
batch picking, 94
bids (proposal responses), 81
Bills of Lading (BOL), 59, 89, 127-128
BLS (Bureau of Labor Statistics), 175
BOL (Bills of Lading), 59, 89, 127-128
bonded warehouses, 223-225
bottlenecks (processes), 89
bracing, 95
break-bulk materials, 226
break-bulk processes, 17
break-pack processes, 48, 213
bulking orders, 18
bulk materials, 226
bulk picking, 94
bulk pick lines, 53
bulky products, 46
bundled shipments, 18
Bureau of Labor Statistics (BLS), 175
business cycles, influence on demand, 152

calculating, space utilization ratios, 100
capacity
  processes, 89
  utilization, 58
carousels, 52, 214
Carriage & Insurance Paid to (CIP), 135
Carriage Paid To (CPT), 135
carriers
  managing the carrier base, 124-125
  warehouse interactions, 121-123
carousels, 48, 92
case studies
  logistics personnel development, 70-75
  warehouse selection and distribution quality, 28-42
Cass Information Systems, Inc., 128
categories, inventory management, 148
cycle stock, 149
in-transit inventory, 150
safety stock, 149
speculative stock, 150-151
cement storage, 226
Certificate of Analysis, 139
Certificate of Certification, 139
Certificate of End-Use, 138
Certificate of Free Sale, 139
Certificate of Inspection, 139
Certificate of Insurance, 140
Certificate of Manufacture, 139
Certificate of Origin, 138
CFR (Cost and Freight), 134
Change of Address (contract Terms and Conditions), 84
Charter Party, 141
checking freight, 91
checking outbound orders, 95
CHR (C.H. Robinson), 125
C.H. Robinson (CHR), 125
CIF (Cost, Insurance & Freight), 135
CIP (Carriage & Insurance Paid to), 135
claims management, 128-129
Claims (contract Terms and Conditions), 84
coil rams, 217
commercial invoices, 137
commodity rates, 127
communication roles, packaging, 118
Confidentiality Agreement (Services Agreement), 83
consolidated services, 196
consolidated shipments, 18
constraints (processes), 89
Consular Invoices, 137, 140
content (contracts), 82
  Services Agreement, 83-84
  Terms and Conditions, 84-85
contracts, 79
  key terms, 85-86
  negotiations, 82
  potential providers, 80-82
  role of, 79
  sections/content, 82
  Services Agreement, 83-84
  Terms and Conditions, 84-85
contract warehousing, 23-25
  cost points of indifference, 27-28
  practical cost differences, 26
conveyor systems, 214-215
Corrective Action Notice (contract Terms and Conditions), 84
Cost and Freight (CFR), 134
cost differences
  cost points of indifference, 27-28
  warehousing strategies, 26
Cost, Insurance & Freight (CIF), 135
cost points of indifference, 27-28, 36
costs
  influence of inventory management, 151-152
  WMS (warehouse management system), 198
cost trade-offs, warehousing and transportation services, 129
  SLC (shipper load and count), 131
terms of sale, 132
  variations in roles, 130-131
Council of Supply Chain Management Professionals (CSCMP), 80
CPT (Carriage Paid To), 135
Crane Worldwide Logistics, 133
criteria, WMS selection, 201
critical performance measures, 102, 106-108
cross-docking, 7, 17-18, 222-223
CSCMP (Council of Supply Chain Management Professionals), 80
CSR (customer service representative), 66
cube utilization (products), warehouse design, 46, 101
cues, safety, 179
  audio cues, 180-181
  odor cues, 181-182
  touch cues, 181
  visual cues, 180
cushioning technology, 95
customer service
  considerations for warehouse design, 51
  implications of inventory management, 152-154
  role of warehousing, 8-10
economies of sale, warehousing support, 3-5
electric rider lifts, 216
electronic information boards, 179
electronic picking tunnels, 48
eliminating variations in processes, 88
employees
  assistance, 67
  training options, 65
enterprise resource planning (ERP), 197
EOQ (economic order quantity) model, 129-130, 149
equipment
  delivery routing models, 168
  safe product movement, 177-179
  safety devices, 177
  utilization, 104-105
equipment
  considerations for warehouse design, 51, 52
  technology, 207
    AGVs (Automated Guided Vehicles), 212-213
    AS/RS (Automated Storage and Retrieval Systems), 211-212
    conveyor systems, 214-215
    forklifts, 215-217
    key terms, 217-219
    piece picking automation, 213-214
  utilization, 61
ERP (enterprise resource planning), 197
errors and reconciliation, inventory management, 155
  cycle counting, 155-156
  physical inventory, 156-157
exchange of information, personnel, 66-67
exponential smoothing, 153
export licenses, 138
export warehouses, 222-225
EXW (ExWorks), 134
ExWorks (EXW), 134

F
facilitation of product flow, distribution centers, 15
  accumulation, sortation, allocation, and assortment, 16-17
  cross-docking, 17-18
  full-line stocking, 17
  key terms, 19-20
  postponement, 18-19
  sequencing, 18
facility location analysis, 163-171
FAK (freight-all-kinds), 127
FAS (Free Alongside Ship), 134
fatalities among warehouse workers, 175
FCA (Free Carrier), 134
feedback, personnel, 67-68
fencing (physical security), 190
FIFO (first-in first-out) process, 47, 151
fire safety, 189
first-in first-out (FIFO) process, 47, 151
fixed costs analysis, warehouse selection, 36
floating warehouses, 227
flow-through distribution facility, 17
FOB (Free on Board) domestic transportation terms of sale, 132-134
Force Majeure Provisions (Services Agreement), 83
forecasting
postponement and, 18-19
sales, inventory management, 152-154
demand, warehouse protection, 6
Foreign-Trade Zones Board, 224
Foreign Trade Zones (FTZs), 190, 223-225
forklifts, 215-217
fourth-party logistics (4PL) providers, 18
forward picking areas, 53, 91
Free Alongside Ship (FAS), 134
Free Carrier (FCA), 134
Free on Board (FOB) domestic transportation terms of sale, 132-134
freight-all-kinds (FAK), 127
freight forwarders, 223
freight payment services, 128-129
freight rates, 126-127
frontline engagement, 62, 69
FTZs (Foreign Trade Zones), 190, 223-225
fulfillment of orders, performance measures, 105
full-line stocking, distribution centers, 17
functional specialization (specialty warehouses), 221-222

G
GENCO, 17, 226
Global 1200 Deepwater Derrick pipeline vessel, 227
global marketing exchanges, 228-229
goods specialization, 225-229
grazing, 184
“The Growth and Development of Logistics Personnel,” 60

H
handling products
industrial packaging, 111
identification and communication roles, 118
key terms, 119
material usage, 114-116
protection roles, 116-118
stabilization impact, 112-114
standardization impact, 112
utilization impact, 112
personnel, 58
warehouse design considerations, 48
hands-free voice technology, 205
Hatcher, George, 29
high-speed conveyor systems, 214
history, warehousing's role in supply chain, 1-3
honeycombing, 29, 100
hydraulic dock levelers, 177

I
iceberg principle, inventory management, 154-155
identification roles, packaging, 118
Import Licenses, 140
import warehouses, 222-225
inbound freight volumes, warehouse selection, 163
inbound loads, 49
INCOTERMS (International Commercial Terms), 133-136
industrial product packaging, 111
identification and communication roles, 118
key terms, 119
material usage, 114-116
protection roles, 116-118
stabilization impact, 112-114
standardization impact, 112
utilization impact, 112
infestation prevention, 189
information exchange, personnel, 66-67
information management tools, 195
hands-free voice technology, 205
key terms, 217-219
RFID (radio frequency identification) technology, 205-207
WMS (warehouse management system), 196
labor management, 200
order fulfillment and inventory management, 199
picking processes, 199
receiving processes, 198
replenishment processes, 199
shipping processes, 199
transportation processes, 199
vendor selection, 200-205
Insurance (contract Terms and Conditions), 84
Insurance Obligations of All Parties (Services Agreement), 83
integrated handling/storage equipment technology, 207
AGVs (Automated Guided Vehicles), 212-213
AS/RS (Automated Storage and Retrieval Systems), 211-212
conveyor systems, 214-215
forklifts, 215-217
key terms, 217-219
piece picking automation, 213
A-Frames, 213
carousels, 214
pick-to-light systems, 213
put-to-light systems, 214
robot technology, 214
integrity (inventory), 49
interdepartmental service-orientation, personnel, 69-70
interfacing
drivers and receiving, 90
supply chain partners, 8
Intermodal Bill of Lading, 140
intermodal shipments, 124
International Commercial Terms (IN-COTERMS), 133-136
international transportation, 133-141
international warehousing, global marketing exchanges, 228-229
in-transit inventory, 150
inventory
  accumulation, sortation, allocation and assortment, 16-17
  control clerks, 59
  integrity, 49
  management, 145
    categories, 148-151
    cost implications, 151, 152
    errors and reconciliation, 155-157
    iceberg principle, 154-155
    key terms, 157-159
    role of, 146-148
    sales forecasts, 152-154
    WMS (warehouse management system), 199
  turnover (performance measure), 107
  variety considerations, warehouse design, 47
  velocity considerations, warehouse design, 47
inverted tariff, 223

J
job shadowing, 65

K
Kanban visual signaling process, 179
Key Performance Indicators (KPIs), 68
key terms
  contracts, 85-86
  distribution centers, 19-20
  inventory management, 157-159
  packaging, 119
  performance, 109-110
  personnel, 76-77
  safety and security, 192-193
  specialty warehousing, 229-230
  technology, 217-219
  transportation, 142-144
  warehouse design and layout, 54-55
  warehouse location selection, 171-172
  warehouse management, 96-97
  warehousing and distribution center strategies, 42-43
  warehousing’s role in supply chain, 12-13
kitting, 50
Knight Transportation, 131
knock-down furniture, 19
knowledge development, personnel, 63-65
KPIs (Key Performance Indicators), 68
Krass, Paul, 70

L
label generation, 50
labor operations
  warehouse personnel, 58-60
  WMS (warehouse management system), 200
layout, warehouses, 45
  key terms, 54-55
  space and time considerations
    aisles, 50
    customer requirements, 51
Index

dedicated and random storage, 49-50
equipment systems, 51-52
future plans and expectations, 53
OS/D and returns, 51
product characteristics, 46-48
product layout and flows, 53
staging and loading docks, 48-49
VAS (value-added services), 50-51

LCI (Logistics Consolidators, Inc.), personnel development case study, 70-75
lead time
customer service, 10
warehouse protection, 6
lead union clerks, 173
leakers, 181
Legal Jurisdiction (contract Terms and Conditions), 84
LeMay, Steve, 60
less-than-truckload (LTL) operations, 17
Liability Provisions and Limitation (Services Agreement), 83
Lien and Security Interest (contract Terms and Conditions), 84
linehaul, 125
liquid material storage, 226
live loads, 48
loading docks, characteristics to consider for warehouse design, 48-49
loading freight, 95
locations (selecting warehouse locations), 161
facility location analysis, 163-171
key terms, 171-172
primary factors, 162-163
Logistics Consolidators, Inc. (LCI), personnel development case study, 70-75
logistics personnel development case study, 70-75
low-cost supply chain strategies, 7
low-lift pallet jacks, 216
LTL (less-than-truckload) operations, 17
lumpers, 95
Lynder, Rich, 31

M
machine technology, 207
AGVs (Automated Guided Vehicles), 212-213
AS/RS (Automated Storage and Retrieval Systems), 211-212
conveyor systems, 214-215
forklifts, 215-217
key terms, 217-219
piece picking automation, 213
A-Frames, 213
carousels, 214
pick-to-light systems, 213
put-to-light systems, 214
robot technology, 214
stretch-wrap, 195
make-bulk processes, 17
management
inventory, 145
categories, 148-151
cost implications, 151-152
errors and reconciliation, 155-157
cycle counting, 155, 156
physical inventory, 156-157
iceberg principle, 154-155
key terms, 157-159
role of, 146-148
sales forecasts, 152-154
key terms, 96–97
loading and shipping, 95
picking and staging, 92–94
process management, 87
  eliminating variations in processes, 88
  process mapping, 88–89
receiving and putaway, 89
  improvements, 91
  interfacing with drivers, 90
unloading and checking, 91
replenishing forward picking areas, 91
managers, 60–61, 67
Manifest, 141
manual walkies, 216
manufacturing
  warehouse support, 3
  warehouse value-added service, 10
marine terminal dockside transit warehouses, 222
market factors, influence on carrier rates, 126
market-oriented firms, 61–62
materials specialization, 225–226
material usage, packaging, 114–116
measures (performance), 99
  critical performance measures, 102, 106–108
  equipment utilization, 104–105
  key terms, 109–110
  order fulfillment, 105
  personnel, 67–68
  space evaluation and utilization, 99–103
  worker productivity, 103–104
merge-in-transit strategy, 19
Mets, Andy, 72
military storage warehouse, 2
mixed pallets, 45
Motor Carrier Act of 1980, 126
moveable bulkheads, 95
moving products, warehouse safety, 177–179

N
NAFTZ (National Association of Foreign-Trade Zones), 224
NAICS (North American Industry Classification System), 175
National Association of Foreign-Trade Zones (NAFTZ), 224
National Motor Freight Classification (NMFC) system, 126
negotiations
  contracts, 82
  transportation services, 125–127
NMFC (National Motor Freight Classification) system, 126
nonasset-based freight brokers, 125
Noncompete Restrictions (Services Agreement), 83
nonconveyable products, 46
nonstackable products, 46
North American Industry Classification System (NAICS), 175

O
OBC (on-board computers), 59
obsolescence, 47
Ocean Bill of Lading, 140
odor safety cues, 181-182
OEM (original equipment manufacturer), 148
on-board computers (OBC), 59
on-time deliveries (performance measure), 107
on-time receiving (performance measure), 107
on-time shipments (performance measure), 107
operating ratios, 130
operations warehouse employees, 64
order cycle time (performance measure), 107
order-fill rate (performance measure), 107
order fulfillment
   customer service, 8-10
   performance measures, 105-107
   WMS (warehouse management system), 199
orders shipped complete (performance measure), 107
original equipment manufacturer (OEM), 148
OS/D (overages, shortages, and damages), 9, 51
outbound orders, 95
outbound shipping clerks, 59
overages, 185
overages, shortages, and damages (OS/D), 9, 51
overhead conveyor systems, 214
Ownership of Goods (contract Terms and Conditions), 84

P
package freight operations, cross-docking, 17
packaging, 111
   considerations for warehouse design, 46
   identification and communication roles, 118
   key terms, 119
   material usage, 114-116
   protection roles, 116-118
   stabilization impact, 112-114
   standardization impact, 112
   utilization impact, 112
Packing Lists, 141
pallet jacks, 58
parallel processing, 89
Payment Provisions (contract Terms and Conditions), 84
performance measures, 99
   critical performance measures, 102, 106-108
   equipment utilization, 104-105
   key terms, 109-110
   order fulfillment, 105
   personnel, 67-68
   space evaluation and utilization, 99-103
   worker productivity, 103-104
personnel, 57
   affirmation, 69
   employee assistance, 67
   fatalities among warehouse workers, 175
   information exchange, 66-67
   interdepartmental service-orientation, 69-70
key terms, 76-77
knowledge development, 63-65
labor operations, 58-60
logistics personnel development case study, 70-75
managers, 60-61
market-oriented firms, 61-62
performance measurement and feedback, 67-68
productivity, 103-104
safety and security
  key terms, 192-193
  physical security measures, 190-191
  picking and replenishing, 182-183
  preventing and reducing accidents, 175-179
  product staging, 183-184
  safety cues, 179-182
physical inventory, 156-157
physical security measures, 190-191
physical stock movement forms, 60
Phyto-Sanitary Certificate, 139
picking
  automation technology, 213
    A-Frames, 213
    carousels, 214
    pick-to-light systems, 213
    put-to-light systems, 214
    robot technology, 214
picking areas, 53
picking cycles, 60
picking lanes, 93
pick-to-light systems, 52, 92, 213
pick tunnels, 52
safety and security, 182-183
warehouse management, 92-94, 199
piece picking automation, 213
  A-Frames, 213
carousels, 214
pick-to-light systems, 213
put-to-light systems, 214
robot technology, 214
pilferage, 184-187
pilfering, 117
points of indifference, 27-28, 36
port activity, influence on supply issues, 151
Porter, Michael, 7
postponement, distribution centers, 18-19
potential providers, 80-82
preventing accidents, 175
  equipment safety devices, 177
  safe product movement, 177-179
  visual safety communications strategies, 176
pricing, transportation services, 125-127
private warehousing, 25
  cost points of indifference, 27-28
  practical cost differences, 26
proactive assistance to employees, 67
process management, 87
  eliminating variations in processes, 88
  key terms, 96-97
loading and shipping, 95
picking and staging, 92-94
process mapping, 88-89
receiving and putaway, 89
  improvements, 91
  interfacing with drivers, 90
  unloading and checking, 91
replenishing forward picking areas, 91
process mapping, 88-89
process performance index, 108
product handling
  industrial packaging, 111
    identification and communication roles, 118
    key terms, 119
  material usage, 114-116
  protection roles, 116-118
  stabilization impact, 112-114
  standardization impact, 112
  utilization impact, 112
personnel, 58
warehouse design considerations, 48
production-oriented firms, 61
productivity, personnel, 103-104
products
  accumulation, sortation, allocation, and assortment, 16-17
  characteristics to consider for warehouse design, 46-48
  condition, 9
  facilitation through distribution centers, 15-20
  overages, 185
  returns, 16-17
  rotation, 151
security, 184
  damaging products, 187-189
  fire and water, 189
  infestation, 189
  key terms, 192-193
  pilferage and theft, 184-187
  security measures, 190-191
staging, 183-184
pro-forma invoices, 137
proposal responses (bids), 81
protection roles, packaging, 116-118
providers, 80-82
public warehousing, 21
  cost points of indifference, 27-28
  practical cost differences, 26
purchasing, warehouse support, 4
push-pull, 114
putaway, warehouse management, 53, 89
  improvements, 91
  interfacing with drivers, 90
  unloading and checking, 91
put-to-light systems, 214
Q
  qualitative traits
    contract warehouses, 23-25
    private warehouses, 25-26
    public warehouses, 21-23
quantitative traits
  contract warehouses, 23-25
  private warehouses, 25-26
  public warehouses, 21-23
R
  radio frequency identification (RFID) technology, 91, 118, 184, 205-207
random storage, warehouse design considerations, 49-50
Rates and Charges (contract Terms and Conditions), 84
Rates and Charges (Services Agreement), 84
Rate Schedule (Services Agreement), 84
ratios (space utilization), 100
receiving
  clerks, 59
  warehouse management, 89
    improvements, 91
    interfacing with drivers, 90
    unloading and checking, 91
  WMS (warehouse management system), 198
receiving operator performance index (ROPI), 104
recessions, influence on demand, 152
reconciliation of errors, inventory management, 155
  cycle counting, 155-156
  physical inventory, 156-157
reconsolidated orders, 18
red/green light trees (visual safety strategy), 176
reducing accidents, 175
refrigerated goods, specialty warehouses, 225
Relocation and Termination (contract Terms and Conditions), 84
replenishing
  safety and security, 182-183
  warehouse management, 91
  WMS (warehouse management system), 199
Request for Information (RFI), 80, 200
Request for Proposal (RFP), 80-81
Request for Quote (RFQ), 81
reserve locations, warehouse design, 53
reserve picking areas, 94
responsiveness to employees, 67
restraints (equipment safety device), 177
returns, products, 16-17, 51
rework areas, 60, 187
RFID (radio frequency identification) technology, 91, 118, 184, 205-207
RFI (Request for Information), 80, 200
RFP (Request for Proposal), 80-81
RFQ (Request for Quote), 81
rider lifts, 216
robot technology, 214
role of industrial product packaging, 111
  identification and communication, 118
  key terms, 119
  material usage, 114-116
  protection, 116-118
  stabilization impact, 112-114
  standardization impact, 112
  utilization impact, 112
roles, warehousing
  supply chain roles, 1-3
  traditional, 3-5
ROPI (receiving operator performance index), 104
rotation of products, 151
routing models, equipment delivery, 168

S
safety, 173
  cues, 179
    audio cues, 180-181
    odor cues, 181-182
    touch cues, 181
    visual cues, 180
key terms, 192-193
physical security measures, 190-191
picking and replenishing, 182-183
prevention and reduction of accidents, 175
  equipment, 177
  safe product movement, 177-179
  visual safety communications strategies, 176
product staging, 183-184
securing products, 184
damaging products, 187-189
fire and water, 189
infestation, 189
pilferage and theft, 184-187
products, 187-189
product staging, 183-184
security cues, 179
  audio cues, 180-181
  odor cues, 181-182
  touch cues, 181
  visual cues, 180
security measures, 190-191
selecting warehouse locations, 161
facility location analysis, 163-171
key terms, 171-172
primary factors, 162-163
sensory-based safety cues
  audio, 180-181
  odor, 181-182
  touch, 181
  visual, 180
sequencing, distribution centers, 18
sequential processing, 89
Services Agreement, 83-84
Services Provided (contract Terms and Conditions), 84
Services to Be Provided (Services Agreement), 83
Severability (contract Terms and Conditions), 85
shelf-life management, 51
Shipments of Dangerous Goods, 141
shipper load and count (SLC) program, 183
Shippers Export Declaration, 138
Shippers letter of Instruction, 141
shipping
  freight, 95
  WMS (warehouse management system), 199
shipping load and count (SLC), 131
shrink-wrap tunnels, 24
Signatures Required (contract Terms and Conditions), 85
single order picking, 53, 92
SKUs (stock keeping units), 17, 47
SLC (shipper load and count) program, 131, 183
slip-sheets, 114
sortation
  conveyor systems, 214
  inventory, 16-17
SOW (Statement of Work), 80-81
space considerations, warehouse design
  aisles, 50
  customer requirements, 51
  dedicated and random storage, 49-50
  equipment systems, 51-52
  future plans and expectations, 53
  OS/D and returns, 51
  product characteristics, 46-48
  product layout and flows, 53
  staging and loading docks, 48-49
  VAS (value-added services), 50-51
special handling services, 50
specialized invoices, 138
specialty warehouses, 221
  functional specialization, 221-222
  import/export warehouses, 222-225
  key terms, 229-230
  materials specialization, 225-226
speculative stock, 150-151
SPI (Supplier Performance Index), 37
stabilization, impact of packaging, 112-114
staging
  docks, 48-49
  safety and security, 183-184
  warehouse management, 92-94
standardization, impact of packaging, 112
start-up costs, 27
Statement of Work (SOW), 80-81
stock keeping units (SKUs), 17
stockouts, 8, 148
storage, warehouse design considerations, 49-50
strategies
  supply chains, 6
    customer service, 8-10
    interfacing between partners, 8
    low-cost strategies, 7
    time-based strategies, 7-8
  visual safety communications, 176
warehousing and distribution centers, 21
  analysis case study, 28-42
  key terms, 42-43
  utility of contract warehousing, 23-25
  utility of private warehousing, 25-26
  utility of public warehousing, 21-23
stretch-wrap, 114, 195
Sugar Creek Candy Company case study, 28-42
supervisory personnel, 60-61
Supplier Performance Index (SPI), 37
supply and demand, 6
supply chain, role of warehousing, 1
  customer service, 8-10
  interfacing between partners, 8
  key terms, 12-13
low-cost strategies, 7
manufacturing and assembly, 10
time-based strategies, 7-8
value-added services, 5-6
surcharges, 127
sustainability, carrier services, 131
Sweet Deal Distribution, Inc. (SDD) case study, 28-42
swivel forks (lifts), 216

T

task interleaving, 58, 183
technology, 217
information technology, 195
hands-free voice technology, 205
RFID (radio frequency identification) technology, 205-207
WMS (warehouse management system), 196-205
key terms, 217-219
machine technology, 207
AGVs (Automated Guided Vehicles), 212-213
AS/RS (Automated Storage and Retrieval Systems), 211-212
conveyor systems, 214-215
forklifts, 215-217
piece picking automation, 213-214
stretch-wrap, 195
temperature controlled goods, specialty warehouses, 225
Termination Provisions (Services Agreement), 83
Term of the Agreement (Services Agreement), 83
Terms and Conditions (contracts), 84-85
terms of sale, transportation, 132
theft, 184-187
third-party logistics (3PL) providers, 16
throughput, 27
tie-high configuration, products, 63
ties (pallets), 124
time-based supply chain strategies, 7-8
time considerations, warehouse design
aisles, 50
customer requirements, 51
dedicated and random storage, 49-50
equipment systems, 51-52
future plans and expectations, 53
OS/D and returns, 51
product characteristics, 46-48
product layout and flows, 53
staging and loading docks, 48-49
VAS (value-added services), 50-51
timely billing (performance measure), 108
timely claim resolution (performance measure), 108
TL (truckload) business models, 4
TMS (transportation management system), 195, 199
TOFC (trailer on flat car), 125
touch safety cues, 181
trade-offs, cost trade-offs between warehousing and transportation, 129
SLC (shipper load and count), 131
terms of sale, 132
variations in roles, 130-131
traditional roles, warehousing, 3-5
trailer on flat car (TOFC), 125
training options, employees, 65
transportation, 121
BOL (Bills of Lading), 127-128
carrier to warehouse interactions, 121-123
cost trade-offs, 129
SLC (Shipper load and count), 131
terms of sale, 132
variation in roles, 130-131
freight payment and claims management, 128-129
influence on warehouse locations, 163
international transportation, 133-141
key terms, 142-144
managing the carrier base, 124-125
pricing and negotiations, 125-127
warehouse support, 4
WMS (warehouse management system) and, 199
transportation management system (TMS), 195, 199
truck driver interfaces, receiving, 90
truckload (TL) business models, 4
turret lifts, 216

U
Uniform Bill of Lading, 140
union clerks, 173
unique functioning/unique materials warehouses, 221
functional specialization, 221-222
import/export warehouses, 222-225
key terms, 229-230
materials specialization, 225-226
unloading freight, 91
U.S. Foreign-Trade Zones Board, 224
utility of contract warehousing, 23-25
cost points of indifference, 27-28
practical cost differences, 26
utility of private warehousing, 25-26
cost points of indifference, 27-28
practical cost differences, 26
utility of public warehousing, 21-23
cost points of indifference, 27-28
practical cost differences, 26
utility tractor (UTR) drivers, 173
utilization
equipment, 104-105
impact of packaging, 112
personnel performance, 103-104
space evaluation, 99-103
UTR (utility tractor) drivers, 173

V
value-added services (VAS)
considerations for warehouse design, 50-51
warehousing, 5
anticipatory inventory, 5
balance of supply and demand, 6
manufacturing and assembly, 10
protection for forecasted demand and lead time, 6
seasonal stocking, 5
variable costs analysis, warehouse selection, 36
VAS (value-added services)
considerations for warehouse design, 50-51
warehousing, 5
anticipatory inventory, 5
balance of supply and demand, 6
manufacturing and assembly, 10
protection for forecasted demand and lead time, 6
seasonal stocking, 5

vendors
compliance management, 51
selection, 200-205

visual safety communications strategies, 176
visual safety cues, 180

W
walkies, 58, 216

Warehouse Liability (contract Terms and Conditions), 84

warehouse management system (WMS), 58
labor management, 200
order fulfillment and inventory management, 199
picking processes, 199
receiving processes, 198
replenishment processes, 199
shipping processes, 199
transportation processes, 199
vendor selection, 200-205

warehousing
Army warehouse history, 2
contracts, 79
key terms, 85-86
negotiations, 82
potential providers, 80-82
role of, 79
sections/content, 82-85
customer service role, 8-10
design and layout, 45
key terms, 54-55
space and time considerations, 46-53
global marketing exchanges, 228-229
management, 87
eliminating variations in processes, 88
key terms, 96-97
loading and shipping, 95
picking and staging, 92-94
process management, 87
process mapping, 88-89
receiving and putaway, 89-91
replenishing forward picking areas, 91
performance measures, 99
critical performance measures, 102-108
equipment utilization, 104-105
key terms, 109-110
order fulfillment, 105
space evaluation and utilization, 99-103
worker productivity, 103-104
personnel, 57
affirmation, 69
employee assistance, 67
information exchange, 66-67
interdepartmental service-orientation, 69-70
key terms, 76-77
knowledge development, 63-65
labor operations, 58-60
logistics personnel development case study, 70-75
managers, 60-61
market-oriented firms, 61-62
performance measurement and feedback, 67-68
role in supply chain, 1-3, 11-13
safety and security, 173
  damaging products, 187-189
  fire and water, 189
  infestation, 189
  key terms, 192-193
  physical security measures, 190-191
  picking and replenishing, 182-183
  prevention and reduction of accidents, 175-179
  product staging, 183-184
  safety cues, 179-182
  securing products, 184-187
selecting locations, 161
  facility location analysis, 163-171
  key terms, 171-172
  primary factors, 162-163
strategies, 21
  analysis case study, 28-42
  key terms, 42-43
  utility of contract warehousing, 23-25
  utility of private warehousing, 25-26
  utility of public warehousing, 21-23
supply chain strategies, 6
  interfacing between partners, 8
  low-cost strategies, 7
  time-based strategies, 7-8
traditional roles, 3-5
transportation interface, 121
  BOL (Bills of Lading), 127-128
  carrier to warehouse interactions, 121-123
  cost trade-offs, 129-132
  freight payment and claims management, 128-129
  international transportation, 133-141
  key terms, 142-144
  managing the carrier base, 124-125
  pricing and negotiations, 125-127
  unique functioning/unique materials, 221
  break and break-bulk materials, 226
  import/export warehouses, 222-225
  key terms, 229-230
  refrigerated and temperature controlled goods, 225
  value-added services, 5
  anticipatory inventory, 5
  balance of supply and demand, 6
  manufacturing and assembly, 10
  protection for forecasted demand and lead time, 6
  seasonal stocking, 5
Warehousing Education and Research Council (WERC), 80
  Warranties (Services Agreement), 83
  water damage prevention, 189
  weight considerations (products), warehouse design, 46
weighted average warehouse location analysis, 163-166
WERC (Warehousing Education and Research Council), 80
wheel blocks, 177
WMS (warehouse management system), 58, 195, 196, 197, 198
  labor management, 200
  order fulfillment and inventory management, 199
  picking processes, 199
  receiving processes, 198
  replenishment processes, 199
shipping processes, 199
transportation processes, 199
vendor selection, 200-205
worker productivity, 103-104

Z
zone picking, 53, 93
zoning laws, 162