Order Condition Standards

What is a normal order cycle time can be substantially altered if the products ordered arrive at the customer location in a damaged or unusable state. Most firms do not wish to absorb the high cost, nor customers the high price, to eliminate the chance of a damaged or inaccurate order. Standards set for package design, procedures for returning and replacing incorrect or damaged goods, and standards set for monitoring order quality will establish how much the order cycle time will be increased on the average.

Order Constraints

Under some circumstances, the logistician may find it desirable to impose a minimum order size, to have orders placed according to a preset schedule, or to have order forms prepared by the customer that conform to preset specifications. These constraints permit important economies to be achieved in product distribution. For example, a minimum order size and precise scheduling of product movements often result in lower transportation costs and increased delivery speed. For some customers, the effective order-cycle time may be lengthened by such a practice. On the other hand, this practice may allow service to be provided to some low-volume markets that might not otherwise be served very frequently or reliably.

IMPORTANCE OF LOGISTICS/SC CUSTOMER SERVICE

Logistics managers may be tempted to dismiss customer service as a marketing or sales department responsibility. We have already noted that buyers do recognize logistics customer service elements as important, often ranking these ahead of product price, product quality, and other marketing, finance, and production-related elements. The key concern at this point is whether it makes a difference to the selling firm in any way that can affect its profitability. How service affects sales and how service affects customer loyalty are questions that need to be explored.

Service Effects on Sales

Logisticians have long believed that sales are affected to some degree by the level of logistics customer service provided. The fact is that logistics customer service represents an element within total customer service, sales cannot be precisely measured against the of levels logistics customer service, and buyers themselves do not always accurately express their desires for service and consistently respond to service offerings. This typically leads logisticians to preset customer service levels and then to design the supply channel around them. Of course, this approach is not ideal, but it is practical.

There is now more definitive evidence that logistics customer service does affect sales. In the careful customer service study by Sterling and Lambert, they were able to conclude that marketing services do affect market share and that the marketing mix components of product, price, promotion, and physical distribution do not contribute equally to market share.[16] Recall that Sterling and Lambert also found that the elements of customer service most important to customers were logistical in nature. Krenn and Shycon were able to conclude from their in-depth interviews of 300 GTE/Sylvania customers that

> . . . distribution, when it provides the proper levels of service to meet customer needs, can lead directly to increased sales, increased market share, and ultimately to increased profit contribution and growth.[17]

Observations[18]

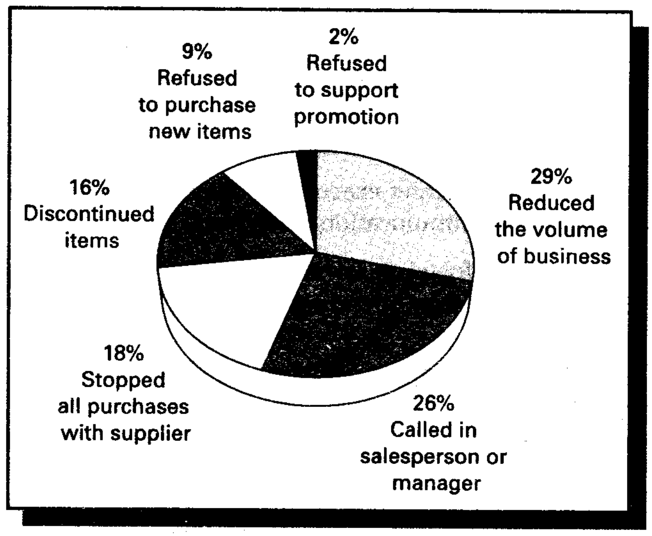
- International Minerals & Chemicals Corporation, after instituting an extensive customer service program, reported a 20 percent increase in sales and a 21 percent increase in earnings.
- A manufacturer reallocated its plant territories and added to its warehouse facilities for an increase in logistics costs of $200,000, a reduction of production costs of $1,400,000, and a net profit increase of $500,000 from an increase in annual sales from $45 to $50 million.
- For a large retail chain with sales of over $1 billion, a consolidation of storage points at five distribution centers was estimated to produce a $9 million saving in cost of goods sold (including inbound freight costs), a $4 million saving in logistics costs, and an additional $10 million increase in net profit resulting from a $100 million increase in retail sales.
- Sigma IT Superstore, Lucknow specializes in sub-distribution, retailing, and small and medium businesses (SMB) solutions. It is a dealer for D-Link, Samsung, IBM, Seagate, and Microsoft. Its customer relationship management (CRM) team was able to reduce the turnaround time for products from 15 days to 7 days. Its revenues grew by 11 percent to touch Rs. 20 crore in 2005–2006.[19]

Baritz and Zissman were able to show that customers (purchasing and distribution executives) can perceive service differences among their "best" and their "average" suppliers.[20] More definitively, they observed that when service failures occur, buyers often impose penalizing action on the responsible supplier. These actions will affect the supplier's cost or revenues. The types of specific actions taken against suppliers are illustrated in Figure 4-5. The researchers were able to conclude with the following strong statement about service effects on sales:

[16]Sterling and Lambert, "Customer Service Research: Past, Present, and Future," pp. 14–17.
[17]John M. Krenn and Harvey N. Shycon, "Modeling Sales Response to Customer Service for More Effective Distribution," *Proceedings of the National Council of Physical Distribution Management*, Vol. I (New Orleans, LA: October 2–5, 1983), p. 593.
[18]Paraphrased in James L. Heskett, "Controlling Customer Logistics Service," *International Journal of Physical Distribution & Logistics Management*, Vol. 24, No. 4 (1994), p. 4–10.
[19]*Express Computers* (April 24, 2006), p. 25.
[20]Baritz and Zissman, "Researching Customer Service: The Right Way," pp. 610–612.

Figure 4-5
Penalties for Customer Service Failures Imposed by Purchasing Agents Against Suppliers

Source: Steven G. Baritz and Lorin Zissman, "Researching Customer Service: The Right Way," *Proceedings of the National Council of Physical Distribution Management,* Vol. II (New Orleans, LA: October 25, 1983), p. 611.



> Differences in customer service performance have been quantified to account for five to six percent of the variations in a supplier's sales.[21]

Similarly, Blanding makes the following statement:

> In industrial markets, a 5% decrease in service levels will result in a 24% drop in purchases by the existing customer base.[22]

Finally, a study by Singhal and Hendricks of 861 publicly held companies found that supply chain failures have an adverse effect on stock prices.[23] When a company announces a supply chain malfunction, such as a production or shipping delay, its stock price can immediately fall 9 percent and by as much as 20 percent over a six-month period. The six most common reasons for supply chain glitches were: parts shortages, changes requested by customers, new product ramp/rollouts, production problems, development problems, and quality problems.

Service Effects on Customer Patronage

Another way to look at the importance of customer service is through the costs associated with customer patronage. Logistics customer service plays a critical role in maintaining customer patronage and must be carefully set and consistently provided if customers are to remain loyal to their suppliers. When it is realized that 65 percent of a firm's business comes from its present customers,[24] we understand why it is so important to maintain the current customer base. As Bender observed,

[21]Ibid., p. 612.
[22]Warren Blanding, "Customer Service Logistics," *Proceedings of the Council of Logistics Management,* Vol. I (Anaheim, CA: October 5–8, 1986), p. 367.
[23]"Study Links Supply Chain Glitches with Falling Stock Prices," *OR/MS Today,* Vol. 28, No. 1 (February 2001), pp. 21ff.
[24]Ibid. p. 366.

On the average it is approximately six times more expensive to develop a new customer than it is to keep a current customer. Thus, from a financial point of view, resources invested in customer service activities provide a substantially higher return than resources invested in promotion and other customer development activities.[25]

The chairman and chief executive officer of AT&T must believe this because when responding to communication price wars, he said:

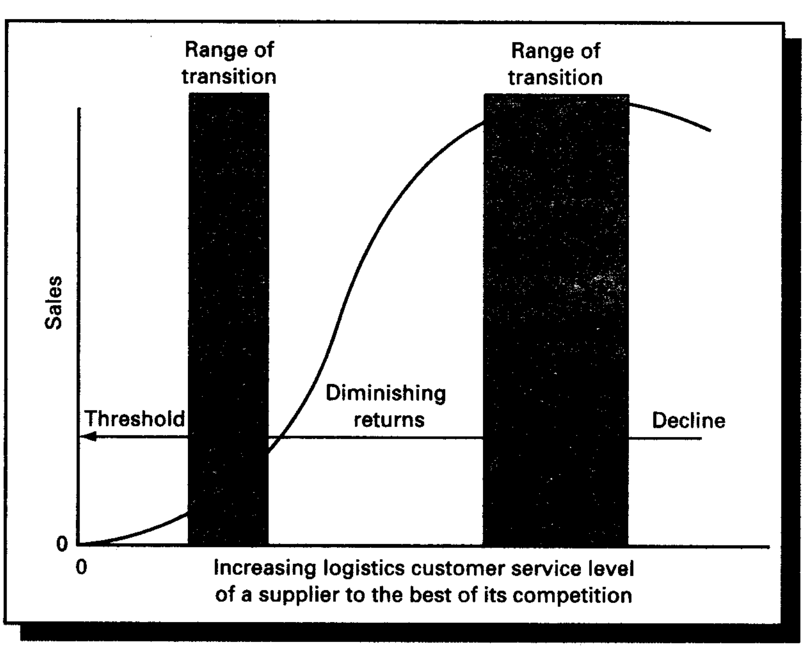
We've got to focus on rewarding and creating loyalty among existing customers rather than spending big to buy back defectors.[26]

Defining a Sales-Service Relationship

The importance of logistics customer service is now clear. However, logistics decision making would be enhanced if we knew more precisely how sales change with changes in logistics customer service levels. We would like to express this effect mathematically as a sales-service relationship. Consider the general nature of such a relationship.

From the available research findings and theories, it is possible to construct what the sales-logistics service relationship must look like, at least in a generalized form. This relationship, shown in Figure 4-6, indicates how sales are likely to change when

Figure 4-6
General Relationship of Sales to Customer Service



[25]Paul S. Bender, *Design and Operation of Customer Service Systems* (New York: AMACOM, 1976), p. 5.
[26]"The 'New' AT&T Faces Daunting Challenges," *Wall Street Journal*, September 19, 1996, B1.

service is improved above that offered by competing suppliers. Note the three distinct stages of the curve: threshold, diminishing returns, and decline. Each stage shows that equal increments of service improvements do not always bring equal gains in sales.

When no customer service exists between a buyer and a supplier, or when service is extremely poor, little or no sales are generated. Obviously, if a supplier offers no logistics customer service and the buyer isn't providing it, there is no way of overcoming the time and space gap between the two. No exchange, and thus no sales, can take place.

As service is increased to that approximating the offering by competition, little sales gain can be expected. Assuming that price and quality are equal, the firm is not, in effect, in business until its service level approximates that of the competition. This point is the threshold service level.

When a firm's service level reaches this threshold, further service improvement relative to competition can show good sales stimulation. Sales are captured from competing suppliers by creating a service differential. As the service is further improved, sales continue to increase, but at a slower rate. The region from the service level at threshold to the point of sales decline is referred to as one of diminishing returns. It is in this region that most firms operate their supply chains.

Why do sales increase with improvements in service? It has been observed that buyers are sensitive to the service that they receive from suppliers.[27] Improved service generally means lower inventory costs for the buyer, assuming that product quality and acquisition price remain unaffected by the improved service offering. Buyers are then motivated to shift their patronage to the supplier offering the best service.

The taper, or diminishing returns, in the curve has been observed in empirical studies.[28] It results both from the buyer's inability to benefit in the same degree from higher service levels as from lower ones, and of purchase policies that require more than one source of supply. The impact that service has on buyers' costs tends to diminish with increased service. Hence, patronage is likely to follow the same pattern. Also, the common purchase policy of maintaining multiple sources of supply puts limits on the degree of sales patronage that any buyer can offer to a supplier. When the policy is to spread purchases across many buyers, the effect is to produce the taper noted in Figure 4-6.

Finally, it is possible that service improvements can be carried too far, with a resulting decline in sales. Whereas improvements in inventory availability, order-cycle time, and condition of delivered goods carry no negative impact on sales, such

[27]Baritz and Zissman, "Researching Customer Service: The Right Way," pp. 610–612; and Ronald P. Willett and P. Ronald Stephenson, "Determinants of Buyer Response to Physical Distribution Service," *Journal of Marketing Research* (August 1969), pp. 279–283.

[28]Ronald H. Ballou, "Planning a Sales Strategy with Distribution Service," *Logistics and Transportation Review*, Vol. 9, No. 4 (1974), pp. 323–333; Willett and Stephenson, "Determinants of Buyer Response to Physical Distribution Service" Nicos Christofides and C. D. T. Watson-Gandy, "Improving Profits with Distribution Service," *International Journal of Physical Distribution & Materials Management*, Vol. 3 (Summer 1973), pp. 322–330; and Krenn and Shycon, "Modeling Sales Response to Customer Service for More Effective Distribution," pp. 581–601.

customer service factors as frequency of vendors' visits to examine buyers' stock levels and take orders, and the nature and frequency of order-progress reporting information may become excessive for some buyers. The buyers may see this as pestering and withdraw sales patronage from a supplier. However, such effects would likely take place only at extreme levels of service when customers become saturated with too much of a seemingly good thing.

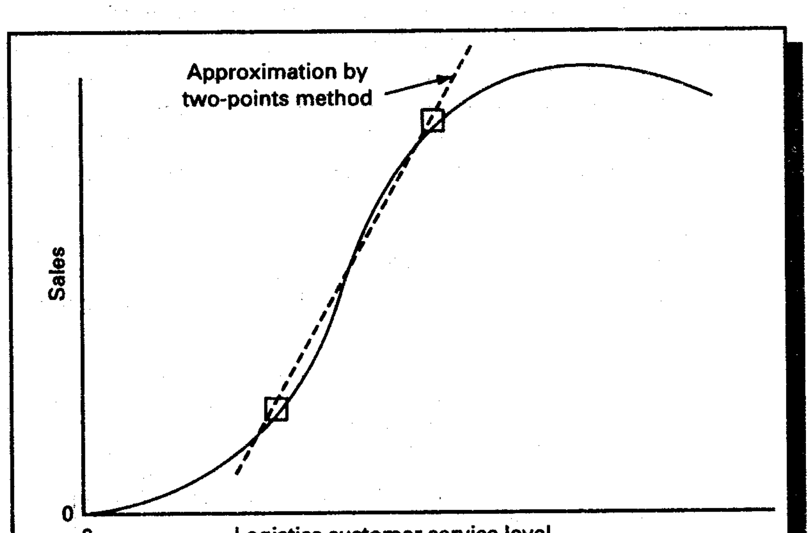
Modeling the Sales-Service Relationship

The sales-service relationship for a given product may deviate from the theoretical relationship shown in Figure 4-6. A number of methods for modeling the actual relationship might be used in specific cases. Four of these are the two-points method, before-after experiments, game playing, and buyer surveys.

Two-Points Method

The two-points method involves establishing two points on the diminishing return portion of the sales-service relationship through which a straight line can be drawn. This line is then used as an acceptable approximation to the curvilinear relationship, as shown in Figure 4-7. The method is based on the notion that multiple data points to accurately define the sales-service curve would be expensive or unrealistic to obtain, and if data were available, it is not usually possible to describe the relationship with a great deal of accuracy.

Figure 4-7
Approximation of a Sales-Service Relationship by the Two-Points Method



The method involves first setting logistics customer service at a high level for a particular product and observing the sales that can be achieved. Then the level is reduced to a low level and sales are again noted. Although the technique seems simple to execute, some methodological problems may limit its usefulness. First, it may not be practical to substantially change the service levels of currently selling products in order to collect the sales response information. Second, the length of time that the service change is in effect, the extent to which customers are informed of the change, and the extent to which other activities are operating that affect sales (promotions, price changes, and product quality changes) may introduce so much variability in the sales results as to render them meaningless. These limitations suggest that a careful selection of the situation to which it is to be applied must be made if reasonable results are to be obtained.

Before-After Experiments

Knowing the sales response to a particular change in service may be all that is needed to evaluate the effect on costs. Generating the sales-service curve over a wide range of service choices may be unnecessary and impractical. Thus, sales response may simply be determined either by inducing a service level change and monitoring the change in sales, or by observing the same effect from historical records when a service change occurred in the past. The service change needs to be great enough so that true sales differences are not masked by normal sales fluctuations or measurement errors.

Before-after experiments of this type are subject to the same methodological problems as the two-points method. However, these experiments may be easier to implement because the current service level serves as the "before" data point. Only the "after" data point is then needed.

Game Playing

One of the more serious problems in measuring the sales response to service changes is controlling the business environment so that only the effect of the logistics customer service level is determined. One approach is to set up a laboratory simulation, or gaming situation, where the participants make their decisions within a controlled environment. This environment attempts to replicate the elements of demand uncertainty, competition, logistics strategy, and others that may be relevant to the particular situation. The game involves decisions about logistics activity levels (and hence service levels) with the objective of generating sales consistent with the costs of producing them. By monitoring the game playing over time, extensive data can be obtained to generate a sales-service curve. Specialized games can be created for this purpose, or generalized logistics games that are available for teaching purposes can be considered.[29]

[29]Examples of these generalized logistics games are found in J. L. Heskett, Robert M. Ivie, and Nicholas A. Glaskowsky, Jr., *Business Logistics: Instructor's Supplement* (New York: Ronald Press, 1964), pp. 100–108; and "Simchip—A Logistical Game," in Donald J. Bowersox, *Logistical Management*, 2nd ed. (New York: Macmillan, 1978), pp. 465–478.

The artificiality of the gaming environment will always lead to questions about the relevance of the results to a particular firm or product situation. To the extent that the predictive value of the gaming process is established through validation procedures, the technique offers the advantage of being able to manipulate the problem elements and the environment without intruding on an ongoing process. In addition, the gaming process can be continued as long as needed to acquire the desired information, and replicated for further validation.

Buyer Surveys

The most popular method for gathering customer service information is to survey buyers or other persons who influence purchases. Mail questionnaires and personal interviews are frequently used because a large sample of information can be obtained at relatively low cost. Some questions in the survey may be designed to determine how buyers would change their patronage or purchase levels among suppliers if the customer service offered were changed to some degree. The composite responses from multiple buyers reacting to different proposed levels of logistics customer service provide the basic data for generating the sales-service curve.[30]

Survey methods, too, must be used with caution because biases can occur. A major bias is the fact that buyers are asked to indicate how they *would* respond to service changes and not how they *do* respond to them. In addition, the questions must be carefully designed so as not to lead the respondents or to bias their answers and yet capture the essence of service that the buyers find important.

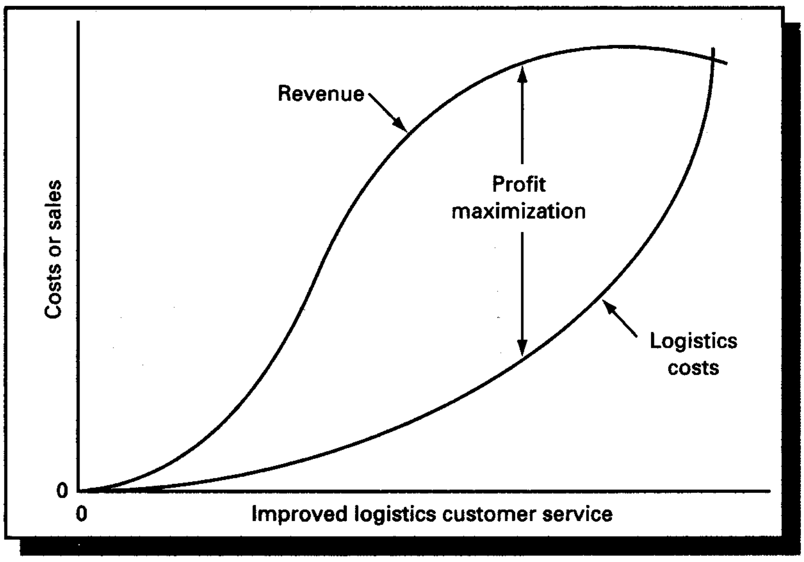
COST VERSUS SERVICE

It was noted earlier that logistics customer service is a result of setting logistics activity levels. This implies that each level of service has an associated cost level. In fact, there are many logistics system cost alternatives for each service level, depending on the particular logistics activity mix. Once the sales-service relationship is generally known, it is then possible to match costs with service, as shown in Figure 4-8.

As activity levels are increased to meet higher customer service levels, costs increase at an increasing rate. This is a general phenomenon observed in most economic activities as they are forced beyond their point of maximum efficiency. The diminishing returns in the sales-service relationship and the increasing cost-service curve result in a profit curve of the form shown in Figure 4-8. The profit contribution curve results from the difference between revenue and costs at various service levels. Because there is a point on the profit contribution curve where profit is maximized, it is

[30]Examples of the use of this technique can be found in Ballou, "Planning a Sales Strategy with Distribution Service"; Perreault and Russ, "Physical Distribution Service in Industrial Purchase Decisions," *Journal of Marketing*, Vol. 10, No. 3 (1976), pp. 3–10; Willett and Stephenson, "Determinants of Buyer Response to Physical Distribution Service"; and Krenn and Shycon, "Modeling Sales Response to Customer Service for More Effective Distribution."

Figure 4-8
General Cost-Revenue Trade-Offs at Varying Levels of Logistics Customer Service



this ideal service level that is sought in planning the logistics system. This maximum profit point typically occurs between the extremes of low and high service levels.

Determining Optimum Service Levels

Once the revenue and logistics cost for each service level are known, we can then determine the service level that will maximize the firm's profit contribution. The optimum profit point is found mathematically. We will consider the theory for doing this, and then look at an example of how the theory is applied in practice.

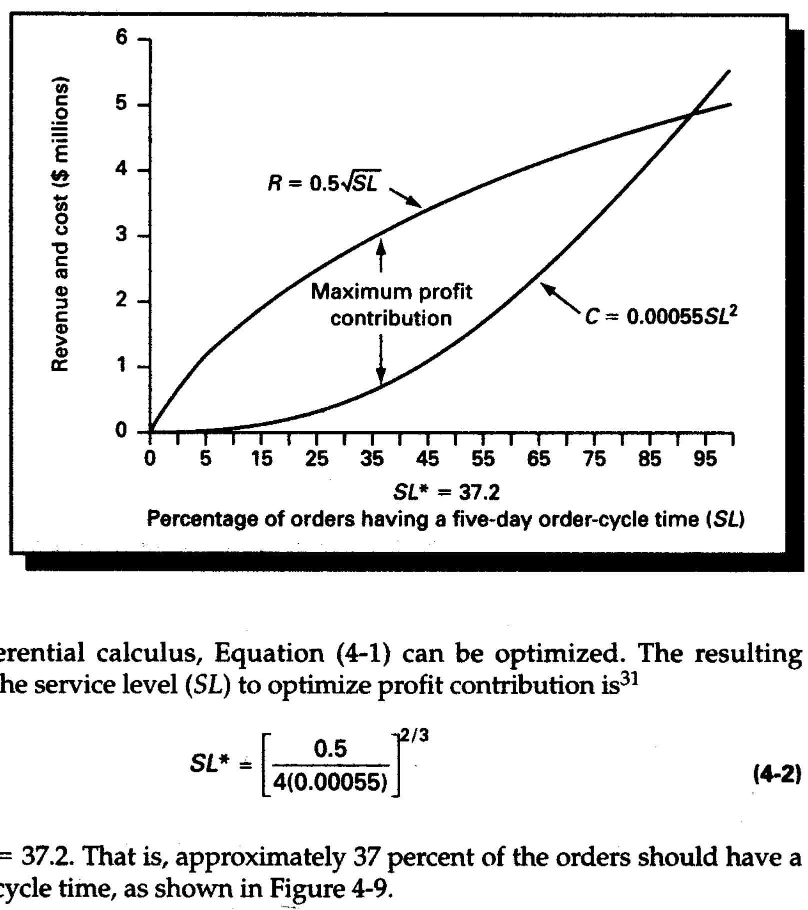
Theory

Suppose that the objective is to maximize the contribution to profit, that is, the difference between logistics-associated revenues and logistics costs. Mathematically, maximum profits are realized at the point where the change in revenue equals the change in cost, that is, marginal revenue equals marginal cost. For purposes of illustration, imagine that the sales-service (revenue) curve is given by $R = 0.5\sqrt{SL}$, where SL is the service level represented as the percentage of orders having a five-day order cycle time. The nature of this curve is shown in Figure 4-9. The corresponding cost curve is given by $C = 0.00055SL^2$. The expression to be optimized is revenue minus cost, or

$$P = 0.5\sqrt{SL} - 0.00055SL^2 \qquad (4\text{-}1)$$

where P = profit contribution in dollars.

Figure 4-9
Maximization of Profit Contribution for Hypothetical Revenue and Cost Curves



Using differential calculus, Equation (4-1) can be optimized. The resulting expression for the service level (*SL*) to optimize profit contribution is[31]

$$SL^* = \left[\frac{0.5}{4(0.00055)}\right]^{2/3} \qquad \textbf{(4-2)}$$

Therefore, $SL^* = 37.2$. That is, approximately 37 percent of the orders should have a five-day order cycle time, as shown in Figure 4-9.

Practice

Consider how the previous theory is applied to warehouse inventory service levels for a manufacturer of food products. One item is selected, but the methodology applies equally to each of the other items in the warehouse.

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[31]The expression of SL^* is determined as follows:

$$P = 0.5\sqrt{SL} - 0.00055SL^2$$

To optimize P with respect to SL, take the first derivative of P with respect to SL and set the result equal to zero. That is,

$$dP/dSL = (1/2)(0.5)SL^{-1/2} - (2)(0.0055)SL = 0$$

Solve for SL^*.

$$SL^* = \left[\frac{0.5}{4(0.00055)}\right]^{2/3}$$

Example

Borden Foods holds a lemon juice product in one of its warehouses. The company holds so much inventory of this product that it would not run out of the product for as long as four years. The service level for the product was set in excess of 99 percent. Although this was one of the company's high-volume products, the question was whether the stock level needed to be set so high.

The general feeling in the company was that a 0.1 percent change in sales would occur for each 1 percent change in service level. The warehouse replenished retail stores on a weekly basis so that the customer service level could be defined as the probability of being in stock during the warehouse replenishment lead time. The trading margin (markup) was \$0.55 per case with annual sales through the warehouse of 59,904 cases. The standard cost per case was \$5.38 and the annual inventory carrying cost was estimated at 25 percent. The replenishment lead time was one week, with average weekly sales of 1,152 cases and a standard deviation of 350 cases.

The optimum service is found at the point where net profit at the warehouse is maximized, or $NP = P - C$. P is gross profit at the location of the warehouse in the supply channel and C is the safety stock cost in the warehouse. Optimality occurs where the change (Δ) in gross profit equals the change in safety stock costs; $\Delta P = \Delta C$. Because the sales response is constant for all levels of service, the change in gross profit is found from

$$\begin{aligned} \Delta P &= \text{Trading margin (\$/case)} \times \text{Sales response (fractional change in sales/1\% change in service)} \times \text{Annual sales (cases/year)} \\ &= 0.55 \times 0.001 \times 59{,}904 \\ &= \$32.95 \text{ per year per 1\% change in service level} \end{aligned} \quad (4\text{-}3)$$

The change in cost is a result of the amount of safety stock that needs to be maintained at each service level. Safety stock is the extra inventory held as a hedge against demand and replenishment lead time variability.[32] This change in safety stock is given by

$$\Delta C = \text{Annual carrying cost (\%/year)} \times \text{Standard product cost (\$/case)} \times \text{Demand standard deviation during replenishment period (cases)} \times \Delta z \quad (4\text{-}4)$$

where z is a factor (called the normal deviate) from the normal distribution curve that is associated with the probability of being in stock during the lead time period. (The rationale for this equation is discussed in the chapter on inventory management.) The change in annual cost is

$$\begin{aligned} \Delta C &= 0.25 \times 5.38 \times 350 \times \Delta z \\ &= \$470.75 \times \Delta z \text{ per year} \end{aligned}$$

for each Δz. The change in safety stock costs for various values for Δz are given in the following tabulation:

[32] See Chapter 9, "Inventory Policy Decisions," for more information on safety stock.

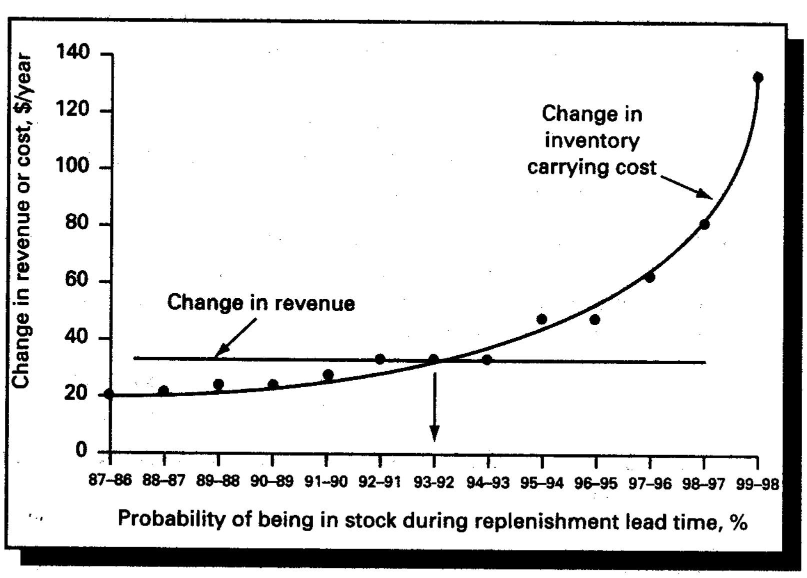
Change in Service Level (SL), %	Change in z (Δz)[a]	Change in Safety Stock Cost (ΔC), $/year
87–86	1.125 − 1.08 = 0.045	$ 21.18
88–87	1.17 − 1.125 = 0.045	21.18
89–88	1.23 − 1.17 = 0.05	23.54
90–89	1.28 − 1.23 = 0.05	23.54
91–90	1.34 − 1.28 = 0.06	28.25
92–91	1.41 − 1.34 = 0.07	32.95
93–92	1.48 − 1.41 = 0.07	32.95 ←
94–93	1.55 − 1.48 = 0.07	32.95
95–94	1.65 − 1.55 = 0.10	47.08
96–95	1.75 − 1.65 = 0.10	47.08
97–96	1.88 − 1.75 = 0.13	61.20
98–97	2.05 − 1.88 = 0.17	80.03
99–98	2.33 − 2.05 = 0.28	131.81

[a]These z values can be found in Appendix A.

Plotting the ΔP and ΔC values on a graph (see Figure 4-10) shows that the optimum service level (SL^*) is 92 to 93 percent. This is the point where the ΔP and C curves intersect.

Note: It is not necessary to account for changes in all product revenue and costs, only the relevant profit and inventory cost effects.

Figure 4-10
Setting the Service Level (SL^*) for an Item in a Food Processor's Line



Borden conducted a similar analysis for a large sample of the thousands of items inventoried in its multiple warehouses. Millions of dollars in inventory cost savings were projected due to stocking at higher levels than could be justified by the added profits to be realized from stocking above the optimum service levels.

SERVICE VARIABILITY

Customer service to this point in the discussion has referred to the average value of the variable representing customer service. However, *variability* in customer service performance is usually more important than average performance. Customers can plan for known and even marginal customer service performance, but variability in service performance is uncertainty. High degrees of service uncertainty cause the customer to incur high costs through elevated inventories, expedited transportation, and additional administrative costs. How much variability to allow is an economic issue. When variability cannot be controlled, information may be used to soften the uncertainty effects.

Loss Function

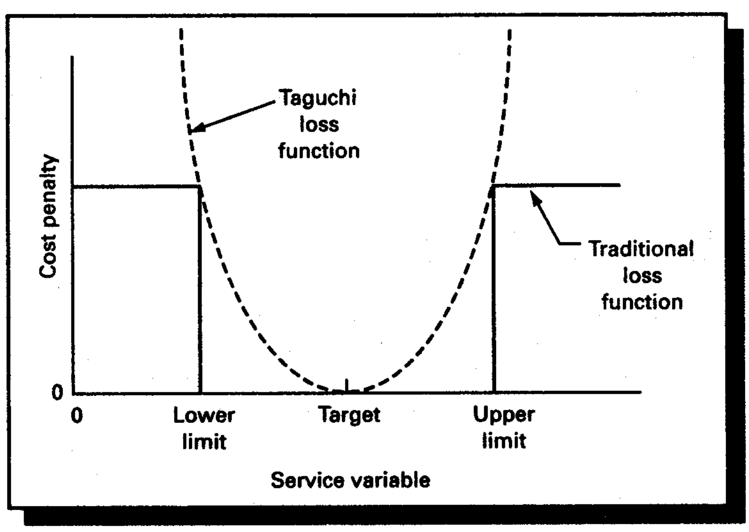
Just as product quality can be judged by its conformance to specifications, logistics customer service can be judged by the extent to which the supply chain processes meet target delivery dates, in-stock frequencies, order-filling accuracy rates, or other service variables. Quality and customer service are similar and, therefore, much of what has been said about product quality in the last 10 to 15 years applies to customer service as well. Genichi Taguchi's loss function is valuable to managing the processes that produce the customer service levels. Taguchi proposed that inconsistent quality in product and services results in expense, waste, loss of goodwill, and lost opportunity whenever the quality target value is not met exactly. Traditionally, quality was viewed to be satisfactory and without cost penalty as long as quality variation remained within the upper and lower limits of an acceptable range (see Figure 4-11). According to Taguchi, losses occur at an increasing rate as service (quality) deviates from its target value. This loss increases at an increasing rate according to the following formula:

$$L = k(y - m)^2 \quad \textbf{(4-5)}$$

where

L = loss in dollars per unit (cost penalty)
y = value of the quality variable
m = target value of the quality variable y
k = a constant that depends on the financial importance of the quality variable

Figure 4-11
Taguchi Loss Function Applied to Logistics Customer Service



When the loss function is known, it places a value on not meeting customer service targets. Along with the cost of adjusting the process to achieve different levels of quality, the process can be optimized for the best level of variability in quality.

Example

Suppose that a package courier service promises to deliver to customers by 10:00 A.M. on the morning after pickup. Delivery later than two hours after the promised delivery time is unacceptable. The company is penalized $10.00 in the form of customer rebate for each late delivery. Converting the penalty to a loss function, the *k* value in the loss function of Equation (4-5) can now be found:

$$L = k(y - m)^2$$
$$10.00 = k(2 - 0)^2$$
$$k = \frac{10}{2^2} = \$2.5 \text{ per hour}^2$$

The value for m is set at 0 since only the deviation y from the target value is sought.

The cost per delivery for controlling the process declines as more deviation is allowed from the target delivery time. The company estimates that process costs are high when there is no deviation allowed from the target value but they decline in a linear fashion from the target value such that process cost = $A - B(y - m)$. The process cost is found to decline with increasing deviation from the target value as $PC = 20 - 5(y - m)$.

The total cost is the sum of the process cost (PC) and the penalty cost (L). The point $y - m$ where the marginal loss equals the marginal process cost is[33]

$$(y - m) = \frac{B}{2k} = \frac{5}{2(2.5)} = 1 \text{ hour}$$

Thus, the company should set its service process to allow no more than one-hour deviation from the target delivery time $m = 0$.

Information Substitution

At times, the uncertainty in customer service performance cannot be controlled to the level that might be desired by customers. In such cases, it may be possible to reduce the impact of the uncertainty by using information as a substitute. One obvious practice is to provide customers with information about their order progress. Order-tracking systems that provide information from the time of order entry until delivery are increasing in popularity. Their use in just-in-time systems is essential to managing the flow of product where little or no inventory is maintained. They are appearing in many retail systems as well. The benefit is that customers know the stage of their order and can anticipate its arrival rather than be in doubt about order progress and unable to plan accurately for delivery delays on inventory levels, production schedules, and the like. A well-designed tracking system should, in addition to providing order-tracking status, give the current estimate of completion times for each stage.

Observation

The Dell Corporation, a manufacturer of personal computers, provides customers using the Internet (and telephone customer service) with the capability to track orders through the *entire* order cycle. When an order is placed through the company's Web site or through a sales person, a tracking number is given to the customer. The customer may then find the order status hyperlink on Dell's Web site and see whether the order has passed the order entry stage, the production stage, or the shipping preparation stage. Order status is updated in real time. Once the order leaves the factory, an interface with UPS or other carrier is also provided on the Web page to track the order through the various stages of delivery to the customer's

[33]Alternately, using differential calculus, the optimal allowed deviation from the target value can be found as follows.

$$TC = A - B(y - m) + k(y - m)^2$$

$$\frac{dTC}{d(y - m)} = 0 - B + 2k(y - m) = 0$$

$$(y - m) = \frac{B}{2k}$$

location. The customer can anticipate within a narrow time window when the order will arrive and can make plans for its receipt.

Service As a Constraint

Customer service is often treated as a constraint on the logistics system when a sales-service relationship cannot be developed. In this case, a predetermined customer service level may be selected, and the logistics system is designed to meet this level with a minimum cost. The service level is often based on factors such as the service levels established by competitors, the opinions of salespersons, and tradition. There is no guarantee that a service level set in this manner will result in a logistics system design that is the best balance between revenues and logistics costs.

In order to move toward an optimum system design when service is treated as a constraint, sensitivity analysis can be used. In this case, sensitivity analysis involves changing the factors that make up service and then finding the new minimum-cost system design. If this type of analysis is repeated a number of times, an array of system costs for various service levels can be obtained, as illustrated in Table 4-3. Although it is not known how logistics system design and the resulting service level affect sales, it is possible to impute a worth to a service level. As shown in Table 4-3, by improving customer service from an 85 percent level to a 90 percent level, logistics

Table 4-3 Logistics System Design Costs As a Function of Various Customer Service Levels

Alternative	Logistics System Design[a]	Annual Logistics Costs	Customer Service Level[b]
1	Mail-order transmittal, manual-order entry, water transportation, low inventory levels	$ 5,000,000	80%
2	Mail-order transmittal, manual-order entry, rail transportation, low inventory levels	7,000,000	85
3	Telephone order entry, truck transportation, low inventory levels	9,000,000	90
4	Telephone order entry, rail transportation, high inventory levels	12,000,000	93
5	Telephone order entry, truck transportation, high inventory levels	15,000,000	95
6	Web site order entry, airfreight, high inventory levels	16,000,000	96

[a]Minimum cost design to produce the stated customer service level.
[b]Percentage of customers receiving goods within five days.

costs will increase from $7 million to $9 million annually. The imputed worth of these five percentage points in customer service improvement is at an added cost of $2 million. Thus, enough of a sales increase from this service improvement must be realized to cover the added logistics costs. The final choice of a service level is left to managerial judgment, but information about the cost of various service levels facilitates the decision-making process.

Measuring Service

Finding a comprehensive measure to effectively assess logistics customer service performance is quite difficult, considering the many dimensions of service to customers. Total order-cycle time and its variability are probably the best single measures of logistics customer service since they embody so many of the variables that are considered important to customers. It can be represented statistically by mean and standard deviations (e.g., for the 95th percentile 10 ± 2 days), or alternatively as a percent of orders meeting target order cycle times.

Customer service may also be measured in terms of each logistics activity. Some common performance measures include the following:

Order Entry

- Minimum, maximum, and average time for order handling
- Percent of orders handled within target times

Order Documentation Accuracy

- Percent of order documents with errors

Transportation

- Percent of deliveries on time
- Percent of orders delivered by customer request date
- Damage and loss claims as a percent of freight costs

Inventory and Product Availability

- Stockout percentage
- Percent of orders filled complete
- Order fill rate and weighted average fill rate
- Average percent of items on backorder
- Item fill rate

Product Damage

- Number of returns to total orders
- Value of returns to total sales

Production/Warehousing Processing time

- Minimum, maximum, and average time to process orders

Many others measures can be used and they should be tailored to the design of the particular logistics system operated by a company.

There are two potential shortcomings to these service measures. First, they are internally oriented to the firm, probably because data are more readily available and control is easier compared to externally oriented measures. On the other hand, they do not promote coordination that is essential to good customer service performance involving multiple channel members. Good externally oriented service measures are yet to be developed.

Second, they may not focus on the needs of the customers. Too often, firms measure customer service in terms of those elements under their direct control. Narrow definitions and measures of customer service may lead a firm to believe that it is performing well, but customers may find the service does not include all the service factors important to them. This leaves the firm unknowingly vulnerable to competitors that recognize the total customer service need and manage service performance from the viewpoint of the customer.

Observation

A major producer of fluid motion control equipment (hoses, connectors, hydraulic cylinders, and control instrumentation) had a substantial market in Latin America. Customer service for the company was measured as the percent of orders shipped (from factory or warehouse) by the customer-requested date. Since customers selected their favorite freight forwarder for ocean transport to Caribbean and South American countries, it would appear that customers should be satisfied. However, the company placed 40 percent of total order cycle time in the hands of their customers. Customers selected the means of transportation from the factories because the company offered no alternatives. With its narrow definition of customer service, the company not only missed the opportunity to use its shipping volume to find lower cost/better ocean service alternatives (such as through a third party logistics provider or 3PL), than the customer could find acting alone, but left itself vulnerable to competitors who sought to manage the customers' entire order cycles.

Service Contingencies

Much of the logistician's planning and control effort is directed toward running an efficient operation under normal conditions. At the same time, preparations must be made to handle those extraordinary circumstances that may shut down the system or drastically alter its operating characteristics in a short time period, such as labor strikes, fire, flood, or dangerous product defects. Two common contingencies are system breakdown and product recall.

System Breakdown

No logistics operating system will run perfectly all of the time. Some service interruptions are bound to occur, but we would not necessarily consider them significant enough to have special plans ready in case of their happening. Expediting a delayed purchase order, handling seasonal ordering peak loads, or having redundant equipment to meet breakdowns—none of these situations really require contingency plans since they are a normal part of business activity.

Example

Federal Express uses "sweep airplanes" to meet surges in volume, weather delays, and equipment failures. The company considers this redundancy a normal part of their highly service-oriented business.

Based on similar arguments, Reliance Retail too is going for its own fleet of such aircrafts.

Contingency planning is different and outside of the normal planning processes. Hale classifies the nature of the event to indicate when contingency planning should be undertaken:

- The probability of occurrence is considered lower than for events included in the regular planning process.
- The actual occurrence of such an event would cause serious damage, especially if not dealt with quickly.
- It deals with a subject about which the company can plan ahead to deal with swiftly if the event occurs.[34]

There are no special methods for contingency planning. It simply is a matter of asking what-if questions about critical elements of the logistics system and setting up appropriate courses of action, should an unexpected event occur to a vital part of the logistics system. Management's desire to ensure the target level of customer service heightens the need to undertake this type of planning.

Application

The West Coast warehouse of a well-known office copying equipment manufacturer burned extensively one Friday afternoon. The warehouse, containing replacement parts for office copiers and general supplies, served a substantial portion of the West Coast area. Considering the competitive nature of that business, the fire represented a potential disaster in lost sales. A portion of the distribution system had broken down.

Fortunately, the company's distribution staff had anticipated this possibility and had contingency plans for just such an event. By Monday, the company had shipped by airfreight enough stock into a public warehouse to be ready for business. Customer service was maintained so near to previous levels that many customers were unaware that the fire had taken place.

[34]Bernard J. Hale, "The Continuing Need for Contingency Planning by Logistics Managers," *Proceedings of Council of Logistics Management*, Vol. I (Atlanta, September 27–30, 1987), p. 93.

Martha and Subbakrishna recognize the particular vulnerability of supply chains due to their design based on speed and efficiency. Quick response, "lean" logistics, and just-in-time deliveries have been encouraged over the last 30 years as a way of reducing inventories, freeing capital, and improving quality. This logistics strategy heightens the risk and impact of disruptions since a continuous flow of product throughout the supply chain with precise timing is required. There are few or no inventories to relieve the shock of disruptions at various stages of the supply chain. The entire supply chain can be at risk of shutdown. The following actions have been suggested to lessen or avoid the impact of sudden supply chain interruptions:

- Insure the risk.
- Plan for alternate supply sources.
- Arrange alternate transportation.
- Shift demand.
- Build quick response to demand shifts.
- Set inventories for disruption possibilities.[35]

Insuring against financial loss is an obvious protection for service breakdowns. However, as insurance companies selectively exclude certain types of risks, such as terrorism, other steps need to be taken. These are generally directed at preserving service levels or keeping customers satisfied during service disruptions.

Maintaining multiple supply sources or planning for alternate suppliers may allow product flow during supply channel disruptions. Reliance on a single supplier source is the major risk. Maintaining a single supply source has been encouraged in recent years by the proponents of just-in-time systems.

Example

When Hurricane Mitch blew through Central America, flooding destroyed banana plantations, two major producers lost much of their area capacity. Dole lost 70 percent of its capacity there, or about one-quarter of its entire capacity. Because Dole had no alternate supply sources, the company experienced a 4 percent drop in revenue.

A number of companies incurred losses and drops in profits due to the heavy rains and floods in Mumbai in the last week of July 2005. Pharmaceutical stocks worth Rs. 180 crore were gutted. Cipla lost stocks worth Rs. 20 crore, Ranbaxy nearly Rs. 22 crore, Lupin about Rs. 3.5 crore, and GSK Pharma nearly Rs. 2 crore.[36] Major consumer durables manufacturers including LG, Samsung, Videocon, Whirlpool, and Godrej & Boyce incurred total losses of Rs. 100 crore.[37] LG alone reported a loss of Rs. 15 crore. The companies claimed these losses from insurance firms, which reported a significant drop in profits.

On the other hand, Chiquita Brands was able to maintain supply. It increased productivity at other locations, such as Panama, and made purchases from associated

[35]Joseph Martha and Sunil Subbakrishna, "Targeting a Just-in-Case Supply Chain for the Inevitable Next Disaster," *Supply Chain Review*, Vol. 6, No. 5 (2002), pp. 18–23.
[36]*Business Line* (July 31, 2005), p. 6.
[37]*Business Standard* (August 12, 2005), p. 4.

producers in the regions that were not damaged by the hurricane. As a result, Chiquita's revenues *increased* by 4 percent in the fourth quarter of 1998.

Transportation is a particularly vulnerable element in the supply channel. Arranging in advance for alternative modes of delivery is the obvious counterresponse to disruptions from strikes, natural disasters, and terrorism. Substituting one mode for another or using alternative routing offers the needed flexibility. Of course, there may be an added cost to keeping the supply chain operating.

Shifting demand is an indirect way to treat supply disruptions. This is the recognition that when one product cannot be made available, customers may be encouraged through incentives to select an alternative product. Sales may be maintained until supply chain performance can be restored.

Example

When an earthquake hit Taiwan in 1999, the supply of components to PC and laptop manufacturers was interrupted for two weeks. Apple Computer faced shortages of semiconductors and components for its popular products. Although attempts were made to ship slower-speed versions of these models, customers complained. Supply problems continued as product configurations were unable to be altered.

By contrast, Dell Computer fared better. Using its product selection Web site to promote special deals and price incentives, Dell was able to shift some demand to other products not affected by the shortages. Earnings actually improved 41 percent during the quarter affected by the supply disruptions.

Similarly, the earthquake that struck Gujarat in January 2001 affected the normal functioning of pharmaceutical and chemical units in the state. Production of dyes and dyestuffs, and intermediaries was affected severely and it took nearly two weeks for the pharmaceutical and chemical units to start normal functioning. This had ramifications on pharmaceutical and textile supply chains throughout the globe.

When terrorists attacked the World Trade Center, the subsequent disruptions to travel suddenly shifted demand to other modes of transportation. When severe winter weather slowed truck travel in northern states, demand shifted to rail. When Russian grain purchases increased the demand for rail hopper cars, regular rail shippers encountered a hopper car shortage. Spikes in demand are frequently not easily absorbed within the normal operation of a supply channel. Planned flexibility is needed. Supply channels built around multiple suppliers or producing points, inventories, and mixed transport methods are best able to handle demand shocks. "Lean" logistics systems are not. Extra capacity and quick response systems may be needed to deal with such unexpected changes in demand levels, probably at additional cost.

Inventories have been a primary way in which companies have dealt with disruptions. They act as a safety net or buffer when demand and supply do not match. Just-in-time and "lean" logistics programs have minimized inventories and increased the negative effect of delays or temporary shutdowns of part of the supply channel. Establishing or increasing inventories at key points in the supply channel can significantly reduce the effects of some type of disruptions.

Actions taken to deal with the risks associated with system breakdowns due to various disruptions in general cause increased costs, unless service is allowed to deteriorate. Although a smoothly running supply chain is the ideal, the reality is that disasters do occur. Responsible managers will take time to anticipate the events that might occur and plan accordingly.

Sometimes, events occur that have such a low probability they are not anticipated at all. Contingency plans cannot be formulated because the events themselves cannot be adequately defined. In such cases, contingency planning may involve having a crisis team in place, ready to be activated when an emergency strikes. Being able to respond quickly and effectively to logistical alternatives as they unfold can be the key to maintaining operations when unforeseen disruptions do occur.

Example

Chrysler activated its logistical command center when terrorists attacked the World Trade Center in New York City, which resulted in the temporary shutdown of domestic air flights and delayed ground transportation at international borders when security was tightened. Chrysler, like other auto producers, was operating its plants under a just-in-time manufacturing system. Very low inventories were held at plants, which relied on a smoothly operating transportation system that can reliably ship small quantities of parts frequently. Even minor disruptions could cause plants to shut down for lack of parts.

The crisis-management team handled the crisis with the following actions:

- Shut the plants down for one day.
- With GM and Ford counterparts, lobby U.S. Customs officials to add more inspectors at the main truck link between Detroit and Ontario, Canada, to ease truck congestion.
- Send word electronically to 150 of its largest suppliers to ship an extra eight to 12 hours' worth of parts to the plants.
- When commercial flights were allowed to resume two days later, truckers en route were instructed to head for the nearest airport where a plane picked up the load and forwarded it to plants in the United States and Mexico.

The result was that plant operations were disrupted for only one day![36]

Product Recall

The rise of consumerism has focused the attention of many companies on the customer with an intensity not previously known. Spearheaded by Ralph Nader, the

[36]Jeffrey Ball, "How Chrysler Averted Parts Crisis in the Logjam Following Attacks," *Wall Street Journal*, September 24, 2001.

consumerism movement has increased the public's awareness of product offerings in general and of defective products in particular. In 1972, Congress passed the Consumer Product Safety Act, which allows the Consumer Product Safety Commission to set mandatory safety standards for products. Some of the awareness is forced. For example, the Consumer Product Safety Commission can require a manufacturer to recall a product to repair it, replace it, or destroy it. Failure to comply may mean civil penalties or imprisonment. These are just the overt, legal actions. Many companies see the failure to manage defective products as leading to the loss of customer goodwill and possible legal repercussions. The point is that the risks are higher than ever for the company that fails to anticipate a product recall possibility.

Contingency planning for product recall involves nearly every function within a business. Those responsible for logistics matters are particularly affected. They are responsible for the logistics channel through which retromovement is likely to take place. Logisticians become involved in product recall in three ways: chairing a task force committee for recall, tracing the product, and designing the reverse logistics channel.

One of the first steps in planning for a future recall, or meeting one that has occurred, is to establish a task force committee to guide the recall efforts. Because the primary duty of such a committee is to pull the product back toward the manufacturer, it is likely that the distribution executive will be the task force chairperson. The committee may also be responsible for stopping production, starting recall action, and carrying out the necessary steps to comply with appropriate regulatory agencies.

Attempting to recall products that cannot be easily located within the distribution system can be a very expensive operation and an unnecessary one, if the recall could have been prevented. Two product-tracing methods seem popular. For years, firms have been coding products by manufacturing location. Because few firms have engaged in further coding as the product moves through various locations in the distribution channel, manufacturing coding can only approximate the final location of products. However, it is readily available.

The second tracing method uses warranty card information. This method has its faults as well. It is confined to those products that use such cards, and not all cards are returned by customers. For better tracing, one electronics equipment retailer requires all customers to fill out an identification card at the point of sale.

Product tracing is being improved markedly using computers. Consider some examples:

- With the use of bar codes, satellite communications, radio-dispatched trucks with on-board computers, and hand-held scanners, Federal Express's COSMOS package tracking system is able to locate a package anywhere in the system.
- Pillsbury, through its Product Control and Identification System, can locate products through the stages of production to retail inventories. It can trace 98 percent of its products within 24 hours, and 100 percent within days.
- Ford Motor Company uses an automated system called North American Vehicle Information System for product tracing. This system can identify each of a vehicle's 15,000 parts for approximately 4 million units sold per year.

- DHL India uses a number of such devices and tools for tracking and tracing of goods-in-transit, and the users can actually trace their shipments on the company's Web site. The company uses global positioning system (GPS) with other technologies and the call center in Singapore updates the Web site periodically.

The final product recall decision concerns how goods are to be moved back through the distribution channel, or reverse distribution system design. Depending on the nature of the product defect and how the company plans to handle it, all or a portion of the distribution channel may be used. Recalled autos are returned only to the dealers' service centers. On the other hand, many small appliances and electronic goods are returned to the factory or regional service centers for repair or replacement.

Example

When CVS Corporation, a leading U.S. retail chain and pharmacy dispenser, receives returned merchandise at a retail store or must recall a item, all merchandise is initially returned to the warehouse serving the store. The manufacturer informs CVS of the disposition of the product. Many manufacturers choose to give CVS credit for the item and have it destroyed on site rather than to pay the transportation and handling charges to have it returned to their factories.

Designing the channel for retromovement requires consideration of product, customer, middleman, and company characteristics, as well as the nature of the defect, market coverage, recall type, remedial program required, current distribution system, and financial capabilities of the company. Although on the surface it may seem the best strategy to recall products from distributors and customers through existing distribution channels, this may not be wise. One possible danger is contaminating the good product flowing in the channel with the recalled product. In such cases, the recalling firm may establish a separate channel (public warehousing and for-hire trucking, for example) to specifically handle the recall. There are as many variants for reverse logistics channel design as there are for product recall circumstances. The logistician should be aware of the variety of channel designs available and should not necessarily confine recalled products to the existing distribution channel.

Why has product recall been considered in a discussion of logistics customer service? Traditionally, goods were considered to flow from manufacturer to consumer. Customer service reflected the idea of supplying a customer, not servicing a customer. Now, however, the consumerism movement, as well as the recycling movement, has generated concern for customer service after the product sale. Thus, the logistician must be concerned with designing product flow channels to satisfy customer needs before and after purchase.

Examples

- When Xerox installs a new, large copier for a customer, the copier is shipped from a central warehouse to a staging location in the customer's area. A local installation crew picks up the copier from the staging facility, transports it to the customer site, and completes the setup. An existing machine, if there is one, is returned to the staging facility, ultimately to be sent to a renovation center in Arizona for refurbishing and resale. The logistician, when planning the staging facility locations, must be concerned with both the forward product movement to customers as well as the return movement of the used copiers. The best staging facility locations may be different when only forward product movement is considered as opposed to product movement in both forward and reserve directions.
- Retail merchants in the United States are often faced with returned items resulting from liberal store return policies and sometimes poor product performance. Since returned items frequently are missing parts or don't work, or the package is no longer presentable, retailers are faced with receiving manufacturer's credit for the item, reconditioning it, or marking it down as an opened item. As an alternative, large merchants such as Wal-Mart may be able to sell these items to Mexican firms that purchase them for a fraction of their retail value but for more than the discounted value that the item may bring on the retail shelf as a reconditioned or opened item. The items are shipped to a Mexican plant where they are refurbished, if practical, and sold as new in the Latin American marketplace. They often sell at a higher price than they commanded in the U.S. market.
- Dell, the largest personal computer (PC) manufacturer in the world, has recalled 4.1 million faulty laptop batteries worldwide in 2006. This was done because the lithium-ion batteries made by Sony could overheat and catch fire. Similarly, Maruti Udyog Limited recalled more than 2,000 Versa vans in 2006 to rectify a fault in the exhaust system noticed during a quality audit at the factory. The company replaced the defective component without any extra cost to the customers. Earlier, the manufacturer of Honda City, recalled over 13,000 automobiles manufactured before April 2004 from Indian market as a gesture of goodwill. The decision follows the failure of one batch of dampers, supplied by vendor Munja Showa, to meet Honda standards.

Concluding Comments

Logistics customer service is the net result of executing all activities in the logistics mix. Although no general agreement exists as to the most appropriate definition of logistics customer service, research seems to indicate that order cycle time and the elements that compose it are among the most critical. Even for overall customer service, logistics components of customer service seem to play a dominant role.

Because customer service has a positive effect on sales, the most appropriate way to approach logistics planning is from a profit-maximization rather than a - cost-minimization viewpoint. Determining how sales respond to service has proven to be quite difficult and of questionable accuracy at best. This has generally led to managers specifying a service level and planning to meet it in the most economical way possible. However, in those cases where demand seems particularly sensitive to service, the sales-service relationship may be determined by one or more of the following methods: two-points method, before-after experimental design, game playing, and buyer surveys. Once this relationship is known, costs may be balanced against revenues so that optimal service levels may be found and the return on logistics assets (ROLA) may be maximized.

Customer service concerns may extend beyond satisfying customers under normal operating conditions. Prudent managers may also plan for the rare case when the logistics system breaks down or a product must be recalled. Preplanned actions for contingent events may prevent a loss of customer goodwill that could take an extended time period to recover once good service performance under normal conditions has been restored. When it is impractical to provide customers with the level of service desired or there are temporary breakdowns in service performance, information in real time about service status may be used to reduce the negative effects of poor service performance.

QUESTIONS

1. Logistics customer service might be quantified in terms of average order cycle time and order cycle time variability. How satisfactory is this as a general statement of logistics customer service? Of customer service overall?
2. What factors make up order cycle time? How do these factors differ, whether orders are filled in a regular distribution channel or are filled through a backup channel when an out-of-stock situation occurs?
3. How is it that customer service results from managing all activities in the logistics mix?
4. What is a logistics sales-service relationship? How does one go about determining it for a particular product line? Of what value is the relationship once it is obtained?
5. How can information, such as an order tracking system, be a substitute for customer service performance?
6. The Cleanco Chemical Company sells cleaning compounds (dishwashing powders, floor cleaners, nonpetroleum lubricants) in a keenly competitive environment to restaurants, hospitals, and schools. Delivery time on orders determines whether a sale can be made. The distribution system can be designed to provide different average levels of delivery time through the number and location of warehousing points, stocking levels, and order processing procedures. The physical distribution manager has made the

following estimates of how service affects sales and the cost of providing service levels:

	Percentage of Orders Delivered Within One Day						
	50	60	70	80	90	95	100
Estimated annual sales (millions of $)	4.0	8.0	10.0	11.0	11.5	11.8	12.0
Cost of distribution (millions of $)	5.8	6.0	6.5	7.0	8.1	9.0	14.0

a. What level of service should the company offer?
b. What effect would competition likely have on the service level decision?

7. Five years ago, Norton Valves, Inc., introduced and publicized a program in which 56 items in its hydraulic valve line would be made available on a 24-hour-delivery basis, instead of the normal 1- to 12-week delivery period. Quick order processing, stocking to anticipated demand, and using premium transportation services when necessary were elements of the 24-hour delivery program. Sales history was recorded for the five years before the service change as well as for a five-year period after the change. Because only a portion of the product family was subject to the service improvement, the remaining products (102 items) served as a control group. Statistics for one of the test product groups showing the before and after annual unit sales levels are given as follows:

	Sales Before Service Change		Sales After Service Change	
Product Family	5-Year Average	Standard Deviation[c]	5-Year Average	Standard Deviation[c]
Test group[a]	1,342	335	2,295	576
Control group[b]	185	61	224	76

[a]Products in the family with 24-hour delivery
[b]Products in the family with 1- to 12-week delivery
[c]For the individual sales

The average value of products in this family was $95 per unit. The incremental cost for the improved service was $2 per unit, but the company did not intend to pass along the costs as a price increase. Instead, it hoped that additional sales volume would more than offset the added costs. The profit margin on sales at the time was 40 percent.

a. Should the company continue the premium service policy?
b. Appraise the methodology as a way of accurately determining the sales-service effect.

8. A food company is attempting to set the customer service level (in-stock probability in its warehouse) for a particular product line item. Annual sales for the item are 100,000 boxes, or 3,846 boxes biweekly. The product cost in inventory is $10, to which $1 is added as profit margin. Stock replenishment is every two

weeks and the demand during this time is assumed normally distributed with a standard deviation of 400 boxes. Inventory carrying costs are 30 percent per year of item value. Management estimates that a 0.15 percent change in total revenue would occur for each 1 percent change in the in-stock probability.

   a. Based on this information, find the optimum in-stock probability for the item.
   b. What is the weakest link in this methodology? Why?

9. An item in the product line for the food company discussed in question 8 has the following characteristics:

   Sales response rate = 0.15% change in revenue for a 1% change in the service level
   Trading margin = 0.75 per case
   Annual sales through the warehouse = 80,000 cases
   Annual carrying cost = 25%
   Standard product cost = $10.00
   Demand standard deviation = 500 cases per 1 week lead time
   Lead time = 1 week

   Find the optimum service level for this item.

10. A retailer has targeted a shelf item to be out of stock only 5 percent of the time (m). Customers have come to expect this level of product availability, so much so, that when the out-of-stock percentage increases, customers seek substitutes and lost sales occur. From market research studies, the retailer has determined that when the out-of-stock probability increases to the 10 percent level (y), sales and profit drop to one-half of those at the target level. Decreasing the out-of-stock percentage from the target level seems to have little impact on sales, but it does increase inventory-carrying costs substantially. The following data have been collected on the item:

Price	$5.95
Cost of item	4.25
Other expenses associated with stocking the item	$0.30
Annual items sold @ 95% in-stock	880

   The retailer estimates that for every one percentage point that the in-stock probability is allowed to vary from the target level, the unit cost of supplying the item decreases according to $C = 1.00 - 0.10(y-m)$, where C is the cost per unit, y is the out-of-stock percentage, and m is the target out-of-stock percentage.

   How much variability from the target stocking percentage should the retailer allow?

11. Appraise the various methods by which a logistics sales-service relationship might be determined. Under what circumstances do you suppose one method might be more appropriate than another? If no sales-service relationship can reasonably be established, how might the logistician still go about designing the logistics system?

12. Discuss the extent of the effect that each order cycle element will have on logistics system design.

13. Outline some of the actions that a logistician might take in the event of a logistics system breakdown caused by the following:
    a. A warehouse fire
    b. A trucker strike
    c. A worker shortage for order processing and order filling
    d. A shortage of a key raw material for manufacturing
    e. The Internet-based transport management system is inoperative
14. Suggest how a product might be traced and what methods might be used to move the product back up the distribution channel in the following product recall situations:
    a. A defective part on an automobile
    b. A defective 27-inch television set
    c. A defective part in a space shuttle
    d. A defective software program for a microcomputer
    e. Contaminated drugs on the retail shelf

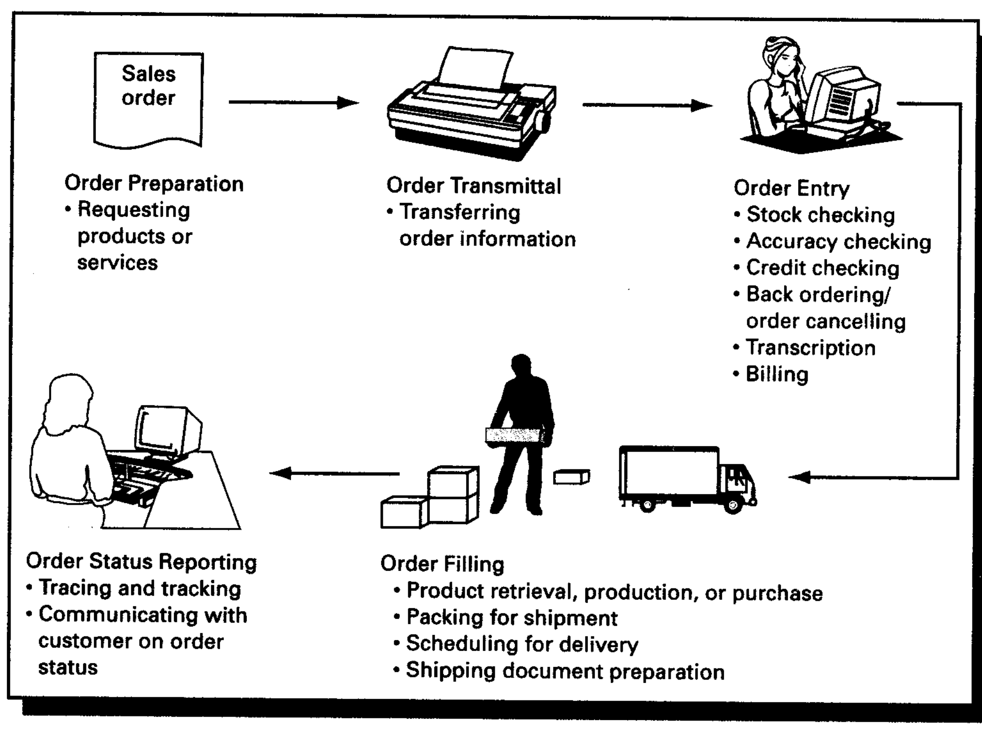


Figure 5-1 Typical Elements of Order Processing

- Some industrial purchase orders are generated directly by the company's computer, often in response to depleted inventory levels. By connecting buyer and seller computers through electronic data interchange (EDI) technology, paperless transactions are accomplished that lower order preparation costs and reduce order replenishment times.

Technology is eliminating the need to manually fill out order forms. Voice-actuated computers and wireless encoding of product information, called radio frequency and identification system (RF/ID), are new technologies that will further reduce the time for the order preparation phase of the customer's order cycle.

Order Transmittal

After order preparation, transmitting the order information is the next sequential activity of the order-processing cycle. It involves transferring the order request from its point of origin to the place where the order entry can be handled. Order transmission is accomplished in two fundamental ways: manually and electronically. Manual transmission can include the mailing of orders or the physical carrying of orders by the sales staff to the point of order entry.

Electronic transmission of orders is now very popular with the wide use of toll-free telephone numbers, data phones, Web sites on the Internet, EDI, facsimile machines, and satellite communications. This almost instantaneous transfer of order information, with its high degree of reliability and accuracy, increasing security, and ever decreasing cost, has nearly replaced manual order transmittal methods.

The time required to move order information in the order processing system can vary significantly, depending on the methods chosen. Sales personnel collection and drop-off of orders and mail transmission are perhaps the slowest methods. Electronic information transfer in its various forms, such as telephoning, electronic data interchange, and satellite communication, is the fastest. Speed, reliability, and accuracy are performance characteristics that should be balanced against the cost of any equipment and its operation. Determining the effects of performance on revenue remains the challenge here.

Observation

Currently, companies debate whether they should be using EDI or the Internet as the preferred method for managing order transmittal. EDI is the older of the two and refers to a dedicated electronic link between the computers of buyers and sellers. It is secure communication, but requires equipment and access to dedicated transmission lines. Transmission costs can be as high as $0.025 per 1,000 characters sent. By way of contrast, the Internet is a low-cost, widely available public forum that uses the standard network of the telephone system. Although improving, security can be an issue and should be the same at both ends of the transmission. There are no standards for the Internet as there can be for EDI. Message delivery is not guaranteed, and it can be longer than for EDI due to message routing protocols that cause delays. However, the modest cost for Internet communication comes from requiring only a local telephone call and the services of an Internet service provider, which can be as low a $10 per month. On balance, many companies have maintained and even expanded the use of EDI in light of the proliferation of Internet use. However, as the Internet technology improves and security is no longer a concern, EDI and Internet communications will merge and become indistinguishable.[3]

Order Entry

Order entry refers to many tasks that take place prior to the actual filling of an order. These include (1) checking the accuracy of the order information, such as item description and number, quantity, and price; (2) checking the availability of the requested items; (3) preparing back-order or cancellation documentation, if necessary; (4) checking the customer's credit status; (5) transcribing the order information as necessary; and (6) billing. These tasks are necessary because order request information is not always in the form needed for further processing, it may not be represented accurately, or additional preparation work may be needed before the order can be

[3]Stuart Sawabini, "EDI and the Internet," *Journal of Business Strategy* (January–February 2001), pp. 41–43; "EDI Delivers for USPS," *Traffic World* (January 11, 1999), p. 36; Tom Andel, "EDI Meets Internet. Now What?" *Transportation & Distribution* (June 1998), pp. 32–34, 38ff; and Curt Harler, "Logistics on the Internet: Freeway or Dead End?" *Transportation & Distribution* (April 1996), pp. 46–48.

	Method of Data Entry	
Characteristic	Keyboard Entry	Bar Code
Speed[a]	6 seconds	0.3 to 2 seconds
Substitution error rate	1 character error in 300 characters entered	1 character error in 15 thousand to 36 trillion characters entered
Encoding costs	High	Low
Reading costs	Low	Low
Advantages	Human	Low error rate Low cost High speed Can be read at a distance
Disadvantages	Human High cost High error rate Low speed	Requires education of the user community Equipment cost Dealing with missing or damaged images

[a]Comparison of speed assumes encoding a 12-character field.
Source: Based on Craig Harmon, "Bar Code Technology As a Data Communications Medium," *Proceedings of the Council of Logistics Management*, Vol. I (St. Louis: October 27–30, 1985), p. 322.

Table 5-1 A Comparison of Data Entry Techniques

released for filling. Order entry may be accomplished by manually completing these tasks, or the steps may be fully automated.

Order entry has benefited greatly from technological improvements. Bar codes, optical scanners, and computers have substantially increased the productivity of this activity. Bar coding and scanning are especially important for entering order information accurately, quickly, and at low cost. In comparison with computer keyboard data entry, bar code scanning offers significant improvement (see Table 5-1). This likely explains the growing popularity of bar coding throughout retailing, manufacturing, and service industries.

In fact, the Retailers Association of India (RAI) and Efficient Consumer Response (ECR) India, spearheading the bar code movement in India, has set a deadline to all suppliers to embrace GS1 bar codes before June 30, 2006. The retailers include names like Shopper's Stop, Pantaloon, RPG Retail, Haiko, Food Bazaar, FoodWorld, Nilgiris, Subhiksha, D-Mart, and HyperCITY, among others.

Observation

Bar coding has been a key to controlling purchasing and inventory costs in large companies such as Wal-Mart and Home Depot. On the other hand, in the medical industry, where cost reduction is a prime concern and where $83 billion per year is spent on medical and surgical supplies, only one-half of all medical supplies are bar coded. It is estimated that $11 billion could be eliminated through improved supply chain practices.

Health care giants such as Columbia/HCA Healthcare and Kaiser Permanente have not been the leaders in bar coding. That distinction goes to St. Alexius Medical Center. Before St. Alexius installed its first scanners a decade ago, it couldn't account for as much as 20 percent of its supply costs. That figure has dropped to as low as 1 percent in some departments, and inventory costs have plummeted 48 percent, or a total of $2.2 million, over the past four years.[4]

Computers are also being used to an increasing extent in the order entry activity. They are replacing the manual stock and credit checking and transcription activities with more automated procedures. As a result, order entry takes only a fraction of the time to complete than it did only a few years ago.

Through the loading of the order-processing and -filling system, the method of order collection, restrictions on order size, and the timing of order entry affect order cycle time. Order design must be closely coordinated with sales order taking. For example, one order entry procedure might have sales personnel collecting orders while they check the trade. Order entry rules may require that the equivalent of a full truckload of order volume be collected by a salesperson before the order is forwarded to an order-processing point. Alternately, the procedures might be adjusted where the customer fills out a standard order form that is required to be mailed by a certain date in order to guarantee that the order will be delivered by a specified date. Further, a restriction might be imposed that only minimum order sizes will be accepted. This would ensure that very high transportation costs would not occur, especially if the supplying firm pays the freight. The revised order entry system might free up salespeople from a nonselling activity, allowing the orders from a large region to be consolidated for more efficient transport routing, and so improve the order-picking-loading patterns on the stocking facility.

Order entry might include the methods that are used to introduce the sales order into the order information system. The options might range from non-electronic transmission of the order information to electronic (computer) breakdown of the order information to ease order picking and processing.

Order Filling

Order filling is represented by the physical activities required to (1) acquire the items through stock retrieval, production, or purchasing; (2) pack the items for shipment; (3) schedule the shipment for delivery; and (4) prepare the shipping documentation. A number of these activities may take place in parallel with those of order entry, thus compressing processing time.

Setting order-filling priorities and the associated procedures affect the total order cycle time for individual orders. Too often, firms have not established any formalized rules by which orders are to be entered and dealt with during the initial stages of order filling. One company experienced significant delays in filling important customer orders when order clerks, during busy periods, would handle the less-complicated orders first. Priorities for processing orders may affect the speed with

[4]"Hospital Cost Cutters Push Use of Scanners to Track Inventories," *Wall Street Journal*, June 10, 1997, 1ff.

which all orders are processed or the speed with which the more important orders are handled. Some alternative priority rules might be the following:

1. First-received, first-processed
2. Shortest processing time
3. Specified priority number
4. Smaller, less-complicated orders first
5. Earliest promised delivery date
6. Orders having the least time before promised delivery date

Selection of a particular rule depends on such criteria as fairness to all customers, the differentiated importance among orders, and the overall speed of processing that can be achieved.

The process of order filling, either from available stock or from production, adds to the order cycle time in direct proportion to the time required for order picking, packing, or production. At times the order cycle time is extended by split-order processing or freight consolidation.

When product is not immediately available for order filling, a split order may occur. For stocked products, there is a reasonably high probability of incomplete order filling occurring, even when stocking levels are quite high. For example, if an order contains five items, each of which has as an in-stock probability of 0.90, the probability of filling the complete order (fill rate, *FR*) is

$$FR = (.90)(.90)(.90)(.90)(.90) = 0.59, \text{ or } 59\%$$

Therefore, partially filling the order from a backup source for the product is more likely than we might first think. As a result, additional order-processing time and procedures will be needed to complete the order.

Split deliveries and a large portion of any additional order information handling time can be avoided by simply holding the order until replenishment stocks for the out-of-stock items are available. This may adversely affect customer service to the point of being unacceptable. Therefore, the decision-making problem is one of trading off the added costs of the increased order information handling and the transportation costs with the benefits of maintaining the desired service level.

The decision to hold orders rather than fill and ship them immediately, for consolidating the order weight into larger but lower per-unit transport cost loads, does require more elaborate order-processing procedures. Increased complexity is a consequence since these procedures must be tied into delivery scheduling to achieve an overall improvement in order processing and delivery efficiency.

Order Status Reporting

This final order-processing activity ensures that good customer service is provided by keeping the customer informed of any delays in order processing or delivery of the order. Specifically, this includes (1) tracing and tracking the order throughout the entire order cycle; and (2) communicating with the customer about where the order may be in the order cycle and when it may be delivered. This monitoring activity does not affect the overall time to process an order.

Observation

Technology has played a major role in order status reporting. Companies such as FedEx and UPS have been leaders in being able to tell customers where their shipments are at any point between origin and destination. Laser-beam bar coding, a worldwide computer network, and specially designed software are key technological elements that drive their tracking systems. The information systems are so sophisticated that they can report who received the shipment and when and where. In addition to telephone support, shippers, armed with only the shipment number, can even track their shipments both nationally and internationally through the Internet.

Dell Computer uses and extends this technology to track an order for a computer from the time of order entry until it is received by the customer. Typical progress stages are order verification and credit checking, time waiting for components, manufacturing, staging for carrier pickup, and routing steps through the delivery process. Customers, knowing their order numbers, can check the order progress throughout the entire order cycle from the company's Web site, or call a customer service center via a toll-free telephone number.

Logistics companies in India are expected to increase the use of truck tracking devices to monitor the movement of vehicles. Nearly three million trucks carry a wide range of products across the country. Chennai-based eLogistics Private Limited offers a patented e-tracking product based on global system for mobile communication (GSM) model. The truck-mounted device costs Rs. 7,500 each and transmits the data while passing a cell phone tower. The company intends to upgrade the product using telematics. It is targeting a sale of 100,000 vehicle tracking devices (VTDs) by the end of 2006–2007. The company is targeting general transporters, the oil industry, and corporates to achieve its target. Till now, eLogistics has installed its tracking solutions at 250 customer locations and VTDs in 5,000 trucks. Eicher has selected eLogistics as its channel partner under which eLogistic's VTDs will be sold along with Eicher's vehicles. eLogistics is holding discussions with Maruti for a similar arrangement. Indian Oil Corporation too has tied up with Bharat Sanchar Nigam Limited and eLogistics to launch a real-time truck tracking solution.[5]

TACO MobiApps Telematics, a part of Tata AutoComp Systems (TACO) group is in negotiations with commercial vehicle manufacturers to consider the possibility of fixing its tracking devices in commercial vehicles. The company's tracking device, Tracko, has been fixed in over 4,000 trucks. The market potential for the tracking device is 2.7 million vehicles.[6]

Order-Processing Examples

The general activities involved in order processing have been identified, but they alone do not indicate how order processing works as a system. Such systems are illustrated through examples from a variety of settings.

[5]*Business Standard* (May 11, 2006).
[6]Available at http://www.tacogroup.com.

Industrial Order Processing

A manual order-processing system is one that has a high component of human activity throughout the system. Some aspects of order processing may be automated or handled electronically, but manual activity will represent the largest portion of the order-processing cycle. Consider how a manufacturer selling to industrial customers designed its order-processing system.

Example

The Samson-Packard Company produces a full line of custom hose couplings, valves, and high-strength hose for industrial use. The company processes 50 orders per day on the average. The order-processing portion of the total order cycle time is 4 to 8 days out of 15 to 25 days. The total order cycle time is long, because orders are manufactured to customer specifications. The primary steps in the order-processing cycle, excluding the order filling activity, are the following:

1. Customer requests are entered into the order-processing system in two ways. First, salespeople collect orders from the field and mail or telephone them to company headquarters. Second, customers take the initiative to mail or telephone their orders directly to headquarters. The customized nature of most customer orders precludes ordering through the company's Web site. Electronic data interchange (EDI) connection with most customers is not available.
2. Upon receipt of telephone orders, a customer service receptionist transcribes the order to an abbreviated order form. Along with the mailed-in orders, the orders accumulated for a given day are passed along to the senior customer service representative, who then tallies the information for the sales manager.
3. The sales manager reviews the order information to keep abreast of the sales activity. He also occasionally writes special notes of instruction on an order about the needs of a particular customer.
4. Next, the orders are sent to the order-preparation clerks, who transcribe the order information, along with special instructions, onto Samson-Packard's standard order form.
5. At this point, the orders are sent to the accounting department for credit checks. They are then forwarded to the sales department for price verification.
6. Next, the data processing department keys the order information into the computer to be used for transmission to the plant, for more convenient handling, and for easy tracing of the order once in process.
7. Finally, the senior customer service representative checks the order in its final form and transmits it via electronic transmission to the appropriate plant. In the same process, an order acknowledgment is prepared for the customer and e-mailed as order verification.

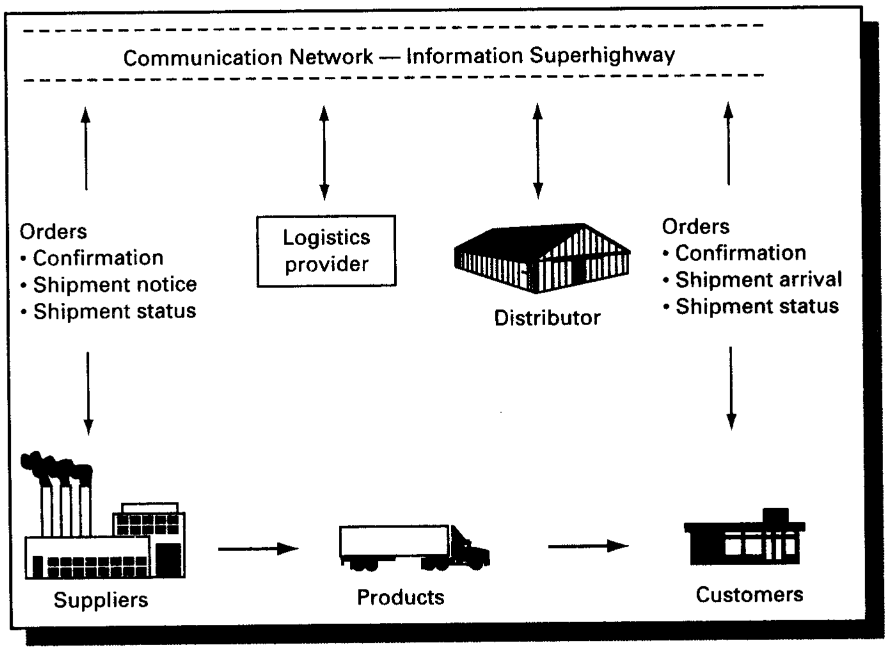


Figure 5-2 Direct-to-Customer Delivery Utilizing the Internet

Retail Order Processing

Companies, such as retailers, that operate intermediate to vendors and customers frequently design their order-processing systems with at least a moderate degree of automation. Very quick order response time is usually not necessary, since there are inventories available for final consumers. These inventories act as a buffer against the indirect effects of the replenishment order cycle. However, replenishment order cycle times that help to maintain a fixed replenishment schedule are important.

Modern information systems have had the benefit of replacing many of the assets previously needed to run a business. Using the Internet, companies have been able to reduce warehouse space, lower inventory levels, reduce handling time, and better track order progress. Consider how a warehouse-free-distribution, direct-to-customer delivery system works.

Example

Finished goods distributors can use EDI to create a direct-from-supplier distribution system. The product does not need to be stored in a distributor's warehouse or on its shelves. Customers receive their goods directly from the supplier. As shown in Figure 5-2, the order information and products flow through the supply chain in the following way:

1. The customers tell the distributor how much of which products are wanted and where via EDI.

2. The distributor tells the suppliers how much of which products must be shipped via EDI.
3. The distributor tells the logistics provider where to pick up product and how much via EDI.
4. The distributor tells the logistics provider how much of which products is to be delivered where and when via EDI.
5. The suppliers prepare the product for shipment.
6. The logistics provider picks up the product, and sorts and segregates the product to the distributor's specifications.
7. The logistics provider delivers the products to the customers.[7]

Customer Order Processing

Order-processing systems that are designed to interact directly with final consumers will be based on elevated levels of customer service. Meeting customer product requests from retail stocks provides almost instantaneous order processing. McDonald's has built a very successful food franchise business on fast order processing. Quick response to customer order requests has often been on the cutting edge of customer service for many companies that sell to the final consumer, especially when the products involved are highly substitutable. As the next example shows, some firms can provide quick response to customer orders even when their place of business is some distance from the customers who can acquire the same products from local retail outlets.

Example

Many remote discount computer hardware and software supply houses have sprung up as competitors to local retail stores. Traditionally, customers would drive to their local retail computer stores and purchase what they wanted on the spot, or, if out of stock, the retailers would in turn order the items from local distributors.

Computer supply houses located at one place in the country can offer customers low prices that result from low overhead and buying economies. However, overcoming location disadvantages is important if these discount houses are to be truly successful. Many have developed a strategy to compress the order cycle time, which usually involves the following steps in the order-processing chain of activities.

1. A customer calls in an order using a toll-free telephone number or enters the order through the company's Web site. Mail is also an option, but it substantially increases order transmittal time.
2. An order taker keys the order request into a computer terminal, or the customer has entered it electronically at the time of order placement. Inventory availability of the items is immediately checked from computerized inventory records, prices are found or calculated, and order charges are computed.

[7]Information from http://www.skyway.com.

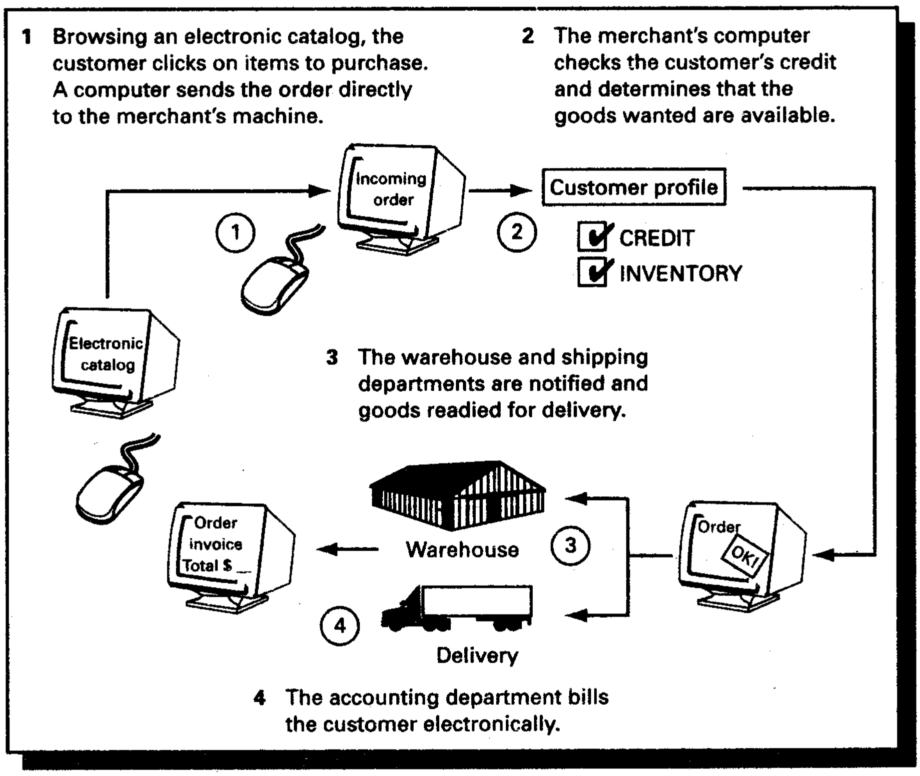


Figure 5-3 Electronic Commerce Through the Internet
Source: "Invoice? What's an Invoice?" *Business Week*, June 10, 1996, pp. 110ff

If method of payment is by credit card, a credit check on the card is conducted electronically.

3. The order request is transmitted electronically to the warehouse to be filled, usually within the same day the order is received.
4. Normally, the order is shipped using UPS, FedEx, or another courier directly to the customer's home or place of business. Overnight delivery may be made for an increased charge, if requested by the customer.

The result is often a total order cycle time that is quicker *and* a price that is lower than what can be offered by local retailers.

Electronic commerce, once practiced by only a few firms such as Wal-Mart, General Motors, and Baxter International, is now becoming a reality for a great many companies. As the security issues are resolved on the Internet, the Internet becomes a driving force to eliminate much of the paperwork in order processing that occurs when one firm sells to another (B2B). E-commerce can reduce the cost of processing a purchase order by 80 percent. Figure 5-3 diagrams how a paperless order-processing system can work using the Internet as the point of order entry.

Example

With its in-house computer expertise and a high-speed intranet, MIT has one of the most sophisticated purchasing systems anywhere. Staff can order pencils and test tubes by clicking through a Web-based catalog, which makes sure nobody spends more than they're authorized to spend. Payments are handled with purchasing cards through American Express. And MIT has contracted with two main suppliers—Office Depot, Inc., and VWR Corp.—to deliver most items within a day or two right to the purchaser's desk, not just a building's stock room.[8]

Indian steel companies have adopted IT-enabled supply chain management (SCM) to reduce cost and time of procurement and delivery. They are also upgrading their online business-to-business (B2B) transaction processes. Online commodity exchange, metaljunction.com, sources major part of inputs for its promoters, Tata Iron and Steel Company Limited (TISCO) and Steel Authority of India Limited (SAIL).[9] It also markets 15 percent of TISCO's, and 7.5 percent of SAIL's production.

Web-Based Channel Order Planning

The low cost of initiating and operating a Web site on the Internet makes it an attractive way for multiple parties to communicate with each other. The Web can be used effectively to plan order flows through a supply channel. This is in contrast to traditional supply planning where a product demand forecast is made, an efficient order size is determined, the order is transmitted to a supplier for replenishment, and after a lead-time period, inventories are replenished from which demand can be served. Each supply channel member (buyer, supplier, carrier, etc.) often operates independently by simply providing a portion of the information required for managing the product flow and responding to immediate requirements, such as filling the order, transporting it, or forecasting demand. If the Internet is integrated into the overall planning process, channel members can easily communicate with each other, share relevant information in real time, and respond quickly and often efficiently to shifts in demand, material shortages, transport delays, and order-filling inaccuracies. Order status is transparent, since all channel members can share a common database, which facilitates tracking and expediting. Low-cost access to the Internet encourages communication among channel partners, which further encourages coordination within the channel, leading to lower ordering costs and improved customer service.

The following example about McDonald's Japan is specific to a more formalized business model referred to as *CFPR®*, which stands for *collaborative planning, forecasting, and replenishment*. Under *CPFR*, supply channel members share information and comanage important business processes in their supply chains. By integrating demand and supply-side processes, *CPFR* will improve efficiencies, increase sales, reduce fixed assets and working capital, and reduce inventory for the entire supply chain, while at the same time satisfying consumer needs. *CPFR* promotes a holistic

[8]"Invoice? What's an Invoice?" *Business Week*, June 10, 1996, p. 112.
[9]Available at http://www.tatasteel.com and http://www.sail.co.in.

view of supply chain management. Impressive results from pilot studies on *CPFR* partnerships have been reported for Wal-Mart, Sara Lee, Branded Apparel, K-Mart, Kimberly Clark, Nabisco, Wegmans Supermarkets, Procter & Gamble, Hewlett Packard, and Heineken USA.[10]

Example

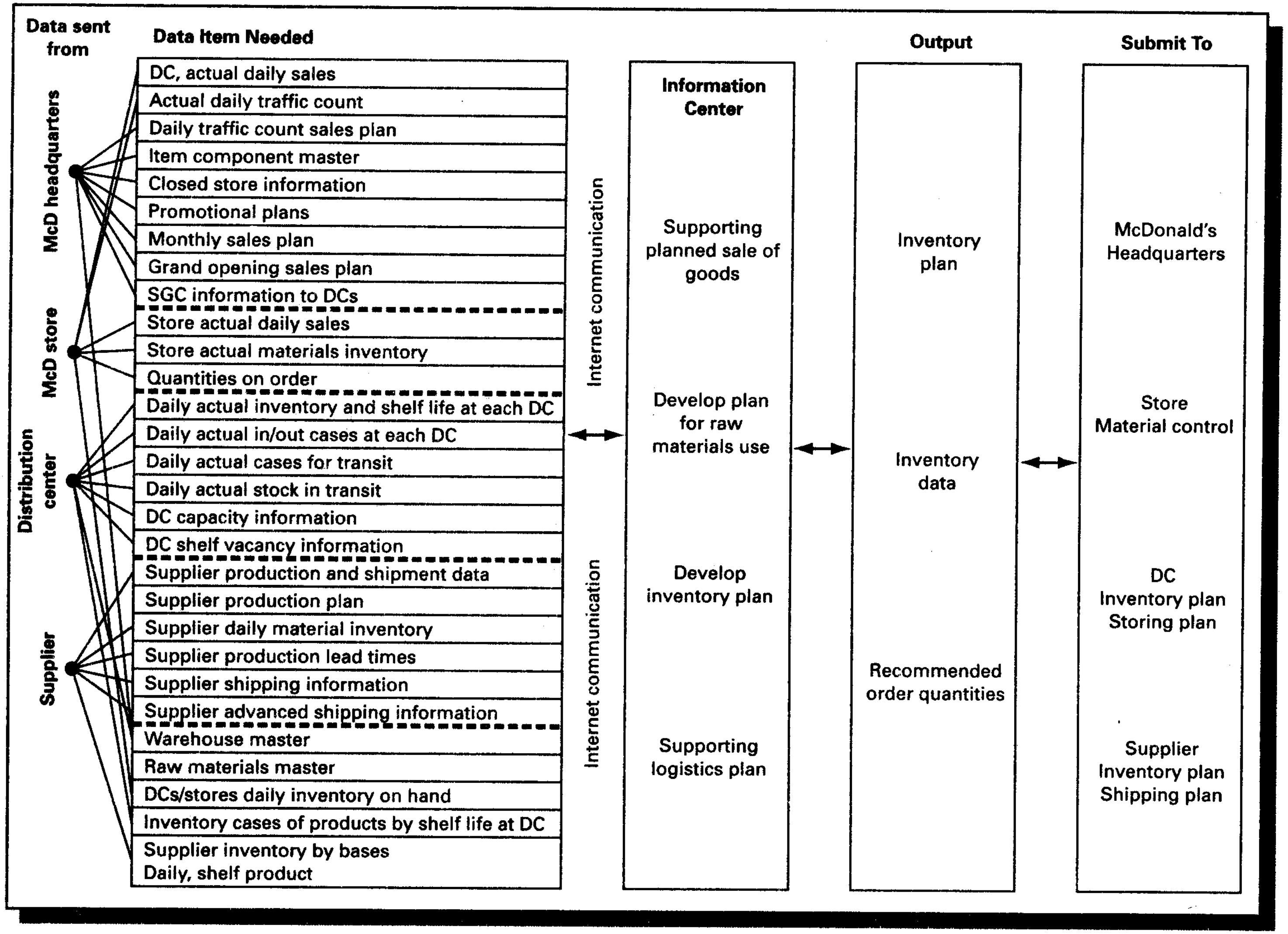
McDonald's Japan operates 3,800 restaurants, with annual sales of about $3.3 billion. More than 3 million customers visit the restaurants each day. There is substantial competition not only from other hamburger restaurants, but also from sushi and ramen (noodles) shops, as well as other sandwich places. The result is a downward pressure on prices and the implementation of many promotions. Traditional forecasting methods, such as time series forecasting, regression modeling, and focus forecasting, do not work well. McDonald's Japan had inventory excesses and shortages, high shipping costs from expedited and uneconomical order sizes, frequent order changes, and inefficient purchase quantities that were the result of poor forecasting of highly variable demand at the store level. As an alternative to store demand forecasting, McDonald's Japan established an information center built around the Internet, whereby stores, headquarters (marketing), distribution centers, and suppliers would communicate and collaborate via the company's Web site to agree on expected sales quantities, order sizes, and supply replenishment delivery schedules.

Each channel member shares information to make the entire system operate smoothly and efficiently. As Figure 5-4 shows, the stores provide initial estimates of customer counts as well as actual sales, current inventory levels, and quantities on order. The distribution centers know quantities in transit, quantities on hand, shelf vacancy information, and the like. Suppliers provide information concerning production schedules, shipping schedules, and capacities. Finally, McDonald's marketing division offers the sales plan, timing of promotions, store expansions and closings, and the like. The information center acts as the hub for decision making, as shown in Figure 5-5.

The information center maintains the Internet servers and helps with the central planning of order quantities and their timing. However, online communication among all parties allows for quick response to unexpected changes in demand and supply, or to demand and supply that are inherently so variable that uncertainties must be countered with high inventory levels. This Web-based ordering system allows suppliers and the distribution centers to respond quickly and efficiently to store needs. Store managers can modify orders in real time up to a freeze date with the result that McDonald's Japan has been able to achieve a 50 percent reduction in the number of restaurant shipments and a 20 percent reduction in restaurant inventories. This may also mean that supplier production cost will be lowered as well. Improved communication in real time and the smoothing of product flow in the supply channel have been keys to these improvements.

[10]Information found at www.cpfr.org; and Sam Dickey, "Forecasting and Ordering System Rides the 'Net,'" *Midrange Systems*, Vol. 10, No. 1 (January 17, 1997), p. 40.

Figure 5-4 Web-Based Order Processing at McDonalds Japa n, Where Data Requirements and Order Planning Transcend Channel-Member Boundaries



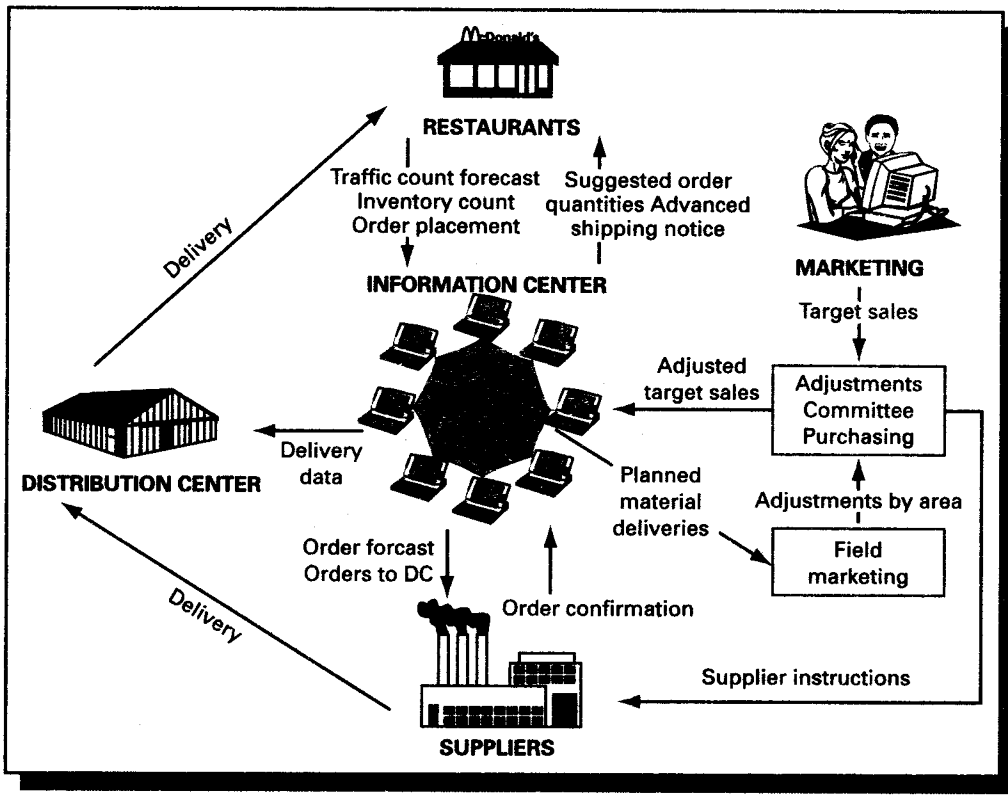


Figure 5-5 Web-Based Order Planning at McDonald's Japan

Other Factors Affecting Order-Processing Time

Selection of the hardware and systems for order processing represent only part of the design considerations. There can be a number of factors to speed up or slow down processing time. These factors result from operating procedures, customer service policies, and transportation practices.

Processing Priorities

Some firms may prioritize their customer list as a way of allocating limited resources of time, capacity, and effort to the more profitable orders. In doing so, they will alter the order-processing times. High-priority orders may be given preferential processing, while low-priority orders may be held for later processing. In other firms, orders may be processed in the order in which they are received. Although the latter approach may seem fair to all customers, it is not necessarily so. It may result in longer processing times, on the average, for all customers as a class. Although there may not be stated order-processing priorities, tacit rules will always be in effect and may adversely affect order-processing times.

Example

A paper manufacturer had no stated priority in processing its orders from food chains for bags and wrapping papers; however, there was an implied order-processing priority. When the processing load became heavy, the order clerks would process the smaller, simpler orders first. The larger orders, which usually were the more profitable ones, were relegated to being processed last.

Parallel Versus Sequential Processing

In some cases, processing times may be significantly reduced by carefully arranging the order-processing tasks. The longest processing times can occur when all tasks are completed in sequence. By undertaking some tasks simultaneously, total processing time can be reduced. Recall the Samson-Packard Company illustration where all order-processing tasks were conducted *sequentially*. Just a simple change of creating multiple copies of an order so that the sales manager could review one copy while transcription and credit-checking activities were being completed on another would somewhat compress the order-processing time (*parallel* processing).

Order-Filling Accuracy

Being able to complete the order-processing cycle without introducing error into the customer's order request is likely to minimize processing time. It is probable that some errors will occur, but their numbers should be carefully controlled if order-processing time is a prime consideration in the company's operation.

Order Batching

Collecting orders from multiple customers into groups for batch processing may reduce processing costs. On the other hand, holding orders until the batch size is realized will likely add to processing time, especially for those orders entering the batch first.

Lot Sizing

A customer order may be too large to be filled from the stocks immediately on hand. Rather than waiting for the order to be completely produced, small lot sizes of the total order quantity may be produced and shipped. Rather than waiting for the complete order, the customer receives her order partially filled and has some of the ordered product available sooner. Although order-processing time may be improved for part of the order, transportation costs are likely to be higher due to shipping several orders of smaller size.

Shipment Consolidation

Much like order batching, orders may be held in order to create an economical shipment size. Consolidating several small orders to build a larger shipping volume reduces transportation costs. Processing time may be increased so that transportation cost may be decreased.

THE LOGISTICS INFORMATION SYSTEM

A logistics information system can be described in terms of its functionality and its internal operation.

Function

The major purpose for collecting, retaining, and manipulating data within a firm is to make decisions, ranging from strategic to operational, and to facilitate the transactions of the business. Larger computer memory space, faster computing, increased access to information throughout the organization from enterprise-wide information systems such as SAP, Oracle, Baan, PeopleSoft, and J. D. Edwards, and improved platforms for transmitting information such as EDI and the Internet have created the opportunity for firms to share information conveniently and inexpensively throughout the supply chain. More efficient logistics operations are possible from the benefits that timely and comprehensive information can provide within the firm, as well as from the benefits of sharing appropriate information among other channel members. This has led companies to think of information for logistics purposes as a logistics information system.

A logistics information system (LIS) can be represented as shown in Figure 5-6. The LIS should be comprehensive and capable enough to allow for communication not only between the functional areas of the firm (marketing, production, finance, logistics, etc.), but also between the members of the supply chain (vendors and customers). Sharing selected information about sales, shipments, production schedules, stock availability, order status, and the like with vendors and buyers has the value to reduce uncertainties throughout the supply chain as users find ways of benefiting from information availability. Of course, there will continue to be a reluctance to openly share information of a proprietary nature that may jeopardize a firm's competitive position. Even though the benefits of information sharing across enterprise boundaries are being recognized, there is likely to be a limit to how much information firms are willing to share with others outside of their control.

Within the LIS, the major subsystems are (1) an order management system (OMS), (2) a warehouse management system (WMS), and (3) a transportation management system (TMS). Each contains information for transactional purposes but also decision support tools that assist in planning the particular activity. Information flows between them as well as between the LIS and the firm's other

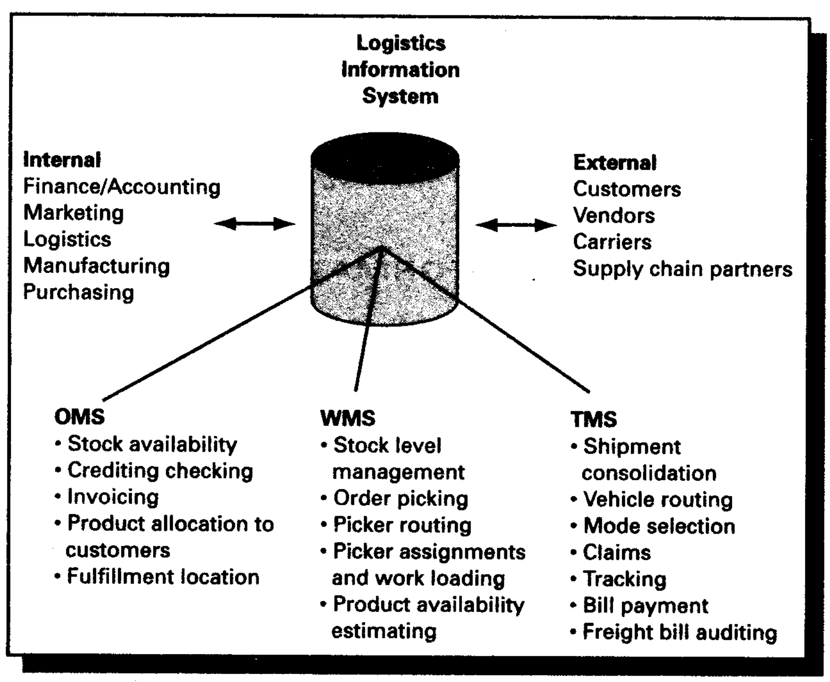


Figure 5-6 Overview of the Logistics Information System

information systems to create an integrated system. The information systems are typically expressed in the form of computer software packages.

The Order Management System

The order management subsystem (OMS) manages the initial contact with the customer at the time of product inquiries and order placement. It is the front-end system of the LIS. The OMS communicates with the warehouse management system to check product availability, either from inventories or from the production schedules. This provides information about the location of the product in the supply network, quantity available, and possibly the estimated time for delivery. Once product availability is acceptable to the customer, credit checking may occur whereby the OMS communicates with the company's financial information system to check customer status and verify credit standing. Once the order is accepted, the OMS will allocate the product to the customer order, assign it to a production location, decrement inventory, and when shipping has been confirmed, prepare an invoice.

The OMS does not stand in isolation from the other information systems of the firm. If the customer is to be served effectively, information must be shared. For example, if the OMS is to provide order tracking, the transportation management system will be interrogated. Communication compatibility is essential.

It should be noted that while the discussion has focused on the orders being received by a firm, there is a similar OMS for the purchase orders placed by the company. Whereas a customer-based OMS will maintain data oriented around the firm's customers, the purchase-based OMS will concentrate on the company's vendors, showing their delivery performance ratings, costs and terms of sale, capabilities, availabilities, and financial strength. Vendors are constantly monitored and reports prepared that assist in optimizing vendor selection.

The Warehouse Management System

The warehouse management system (WMS) may contain the OMS, or it may be treated as a separate entity within the LIS. The WMS must at least tie back to the OMS so the sales department knows what is available for sale. It is an information subsystem assisting in the management of product flowing through and stored in the facilities of the logistics network. The key elements can be identified as (1) receiving, (2) putaway, (3) inventory management, (4) order processing and retrieving, and (5) shipment preparation. All of these elements will appear in the WMS of a typical distribution warehouse, but some may not be present in warehouses used primarily for long-term storage or those having very high turnover.

Receiving. This is the entry or "check-in" point for information into the WMS. Product is off-loaded from the receiving carrier at the warehouse's inbound dock and identified by product code and quantity. Data about the product are entered into the WMS using bar code scanners, radio frequency (RF) data communication terminals, or manual keyboards. Weight, cube, and package configuration of the product are known by matching the product code against an internal product file.

Putaway. The incoming product needs to be temporarily stored within the warehouse. The WMS retains the space layout within the building and the inventory stored in the locations. Based on available space and stock layout rules, the WMS assigns the incoming product to a specific location for later retrieval. If multiple products are to be stored in multiple locations on the same trip, the WMS can specify the putaway sequence and route to minimize travel time. The stock level at each affected location is incremented and the inventory location record is adjusted.

Inventory management. The WMS monitors the product levels at each stocking location in the warehouse. If inventory levels are under the local control of the warehouse, then the replenishment quantities and timing are suggested according to specified rules. The request for replenishment is transmitted to the purchasing department or directly to vendors or company plants through EDI or the Internet.

Order processing and retrieving. Planning for stock retrieval in the warehouse, that is, picking the items requested on an order, is perhaps the most valuable aspect of the WMS. Stock retrieval is the most labor intensive and usually the most expensive part of warehouse operations.

The WMS, with its internal decision rules, will, upon receiving an order, decompose the order into item groups that require different types of processing and picking. Items will be grouped according to the location where inventory is stored. Some items require picking in small, split case quantities, whereas others are picked in full-case or pallet-load quantities. Still others may be picked from separate, secured areas of the warehouse. Each area has different picking characteristics to the extent that it is inefficient to simply pick the order in its entirety in one pass through the warehouse. The WMS splits the order judiciously for efficient order picking and schedules the order flow through the various areas of the warehouse so that the items arrive at the shipping dock as a complete order and in the proper sequence with other orders to be loaded onto a truck or railcar for delivery.

In addition, the WMS subdivides the items within an order-picking area among the order pickers to balance picker workload. Then, items assigned to a particular worker are sequenced for picking to minimize distance traveled, bending and fatigue, and picking time.

Shipment preparation. Orders are often picked in waves through the warehouse, meaning that from among all orders, a subset will be processed at one time. The size of this order subset and the orders within it are selected based on shipment considerations. Orders for customers located within the same proximity are picked simultaneously to arrive at the shipping dock and truck stall at the same time. Estimates are made of cube and weight of the multiple customer orders to be placed on a truck, container, or rail car. Color-coding the merchandise flowing from the different areas of the warehouse aids in assembling the merchandise common to an order and sequencing it onto the delivery vehicle for most efficient routing. In the case of retail merchandise, price tags may be affixed so that the items may be placed on retail shelves without further handling.

Overall, the WMS aids managing warehouse operations in the form of labor planning, inventory-level planning, space utilization, and picker routing. The WMS shares information with the OMS and TMS to achieve integrated performance.

Example

A large drug store chain receives weekly orders from several hundred of its retail stores, or about 50 orders per day in a particular warehouse. A local warehouse supplies stores with general merchandise. Pharmaceuticals are supplied from a centralized warehouse. Upon receipt of the orders at company headquarters, the orders are split between the two product categories. Pharmaceutical orders are filled first and shipped to the local warehouse, to be merged with the general merchandise part of the order going to the same store. Then, at the local warehouse, orders are further split into items that are picked from split-case, full-case, bonded (secured), and bulk areas. Since about 8,000 of the 12,000 items stocked in the warehouse require picking from split-case areas, good management of this labor-intensive area is essential. To do this, the portion of the items in the split-case picking area is further subdivided for each order picker. The order picker processes only those items in his or her immediate zone. The picking sequence of the items is established from the routing rules within the WMS.

The WMS controls the timing for the start of picking in all the areas of the warehouse so that the elements of the order arrive at the shipping dock at approximately the same time. Identifying stickers are placed on the cartons and tote boxes so that the complete order may be assembled at the shipping dock for loading onto a delivery truck that will ultimately contain as many as five separate store orders.

Every time stock replenishment merchandise from vendors is received, information about the incoming products is then entered into the WMS. The WMS then assigns the product to storage locations and maintains a record of the age of the product to control retrieval sequencing.

The Transportation Management System

The transportation management system (TMS) focuses on the inbound and outbound transportation of a firm and is an integral part of the LIS, as shown in Figure 5-6. Like the WMS, it shares information with other LIS components, such as order content, item weight and cube, quantity, promised delivery date, and vendor shipping schedules. Its purpose is to assist in the planning and controlling of the firm's transportation activity. This involves (1) mode selection, (2) freight consolidation, (3) routing and scheduling shipments, (4) claims processing, (5) tracking shipments, (6) and freight bill payment and auditing. A particular firm's TMS may not contain all of these elements. Each activity will be discussed in light of informational requirements and decision assistance provided by the TMS.

Mode selection. Many firms transport in multiple shipment sizes that result in multiple freight services to consider. Transport service choices typically range from small airfreight and ground package carriers to ocean container and rail carload movements. The TMS can match shipment size with transport service cost and performance requirements, especially where there are competing choices involved. A good TMS will store data on multiple modes, freight rates, expected shipment times, mode availability, and service frequency and will suggest the best carrier for each shipment.

Freight consolidation. A very valuable function for the TMS is to suggest the patterns for consolidating small shipments into larger ones. Since a primary characteristic of freight rates is that unit shipping costs drop disproportionately as shipment size increases, shipment consolidation can result in substantial transport cost savings, especially when shipment sizes are small. The TMS can keep track of, in real time, shipment sizes, destinations, and promised delivery dates. From this information and using internal decision rules, economical loads can be built while considering delivery service goals.

Routing and scheduling shipments. When a firm owns or leases a fleet of vehicles, careful management is required to ensure that the fleet is operated efficiently. With order information from the OMS and order-processing information from the WMS, the TMS assigns loads to vehicles and suggests the sequence in which the vehicle stops should be made. Time windows during which stop offs can be made, pickup of returning merchandise from the stop off points, planning for back hauls, driver restrictions on length of driving and rest breaks, and utilization of the fleet across multiple time periods all need to be considered. The TMS retains data on stop locations; vehicle type, number, and capacity; stop loading/unloading times; stop time windows; and other restrictions on the route. Given this background information, shipments to be made in the current period are planned using decision rules or algorithms imbedded in the TMS.

Claims processing. It is inevitable in transportation that some shipments will be damaged. By retaining such information as shipment content, product value, carrier used, origin and destination, and liability limits, many claims can be processed automatically or with minimal human intervention.

Tracking shipments. Information system technology has played a major role tracking the progress of shipments once they have been transferred to transport carriers. Bar coding, radio transmission en route, global positioning systems, and on-board computers are key information system elements that allow the location of shipments to be known in real time. Tracking information from the TMS can then be made available to the shipments' receivers through the Internet or other electronic means. Even estimates of arrival times can be calculated.

The small-shipment carriers such as DHL, Airborne Express, FedEx and UPS are at the forefront in such information system development, since it is customer satisfaction that they sell. Guaranteed delivery service is often promised, and a sophisticated shipment tracking system helps fulfill the goal.

Application

Federal Express bar codes every shipping document with a unique number for easy and rapid identification of a package throughout its journey. The bar code is scanned at the point of entering the delivery system, at sorting, during delivery, and at the destination point. Installed in the delivery trucks are small computers that accept radio communications. This allows the trucks to be routed for pickups and deliveries, as well as to serve as a data input point for information about shipment and truck location. The delivery agent carries a handheld scanner that reads the shipment number at the time of pickup or delivery. The scanning device, with its coded information, can be plugged into the truck's on-board computer and read into the database of the company's transportation information system.

Satellite communication and global positioning systems represent the latest technologies to be integrated into tracking systems. In just-in-time systems, where uncertainties in shipment arrivals can cause serious consequences for production operations, navigational satellites are being used to identify the exact location of truckload shipments as they move through the distribution pipeline and to maintain real-time communication with drivers to report breakdowns and delays, and to estimate arrival times.

Application

A contract trucking company is now using a two-way mobile satellite communication and position-reporting system to monitor the location of its trucks in order to improve performance under just-in-time programs. The heart of the system is a small in-truck computer that is able to communicate with a navigational satellite. The satellite can pinpoint the geographical location of the truck anywhere. Messages between drivers and headquarters may be exchanged without the need of telephone communication.

Presently, most logistics companies in India use PCO calls or SMS as truck tracking devices to monitor the movement of vehicles. There is a sufficient resistance from drivers to e-tracking products based on GSM model discussed earlier.

Freight bill payment and auditing. Determining the freight charges for shipments can be complicated because of the many exceptions that can be placed on freight rates. Since carriers charge only the lowest applicable rate, when a rating error occurs, the shipper can make a claim on the carrier for the difference between the actual charges and the lowest charges. It is the responsibility of the shipper (party purchasing the transportation service) to audit freight bills for these errors and apply for a rebate from the carrier. Freight bill auditing can be a labor-intensive activity due to the large number of routes and rate combinations. The computer-based TMS can quickly search for the minimum cost routing and compare the cost to that on the freight bill.

Freight bill payment can also be facilitated in the TMS. Rather than a decision-assisting use of the TMS, bill payment is a transactional activity. Here the TMS records that shipment has been made and requests the company's financial information system to execute payment to the carrier, often electronically.

Only a limited description of the LIS and its components can be provided since the features vary with the needs of a particular application. For example, some warehouse management systems might further include radio frequency control of all tasks, standards and performance measures, stock cycle counting, and dock scheduling, to name a few. The TMS might include mode selection, routing of full vehicle loads, and performance measurement of carriers. However, some of the fundamental capabilities of the LIS have been discussed that illustrate how information technology is having an impact on the planning and control of operations.

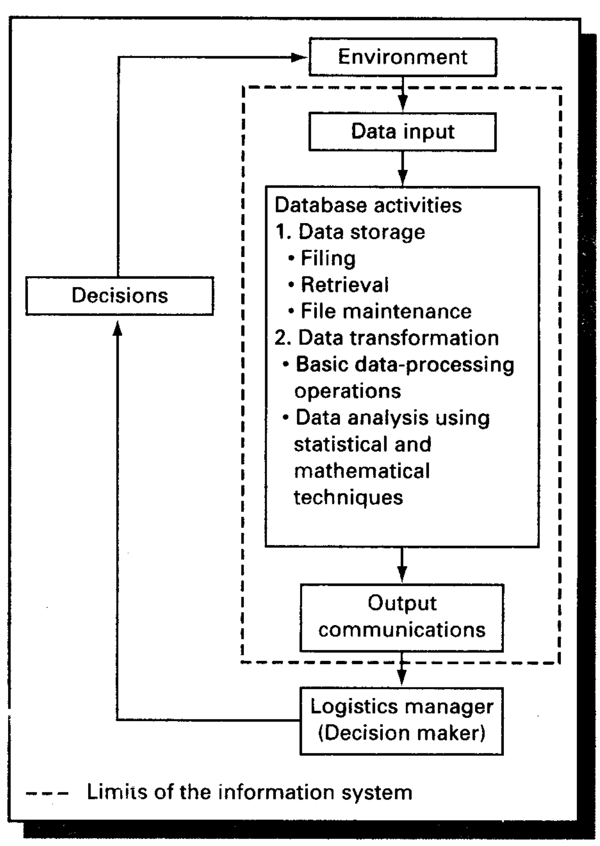
Internal Operation

From the viewpoint of internal operation, a logistics system can be represented schematically, as shown in Figure 5-7. Note three distinct elements that make up the system: (1) the input, (2) the database and its associated manipulation, and (3) the output. Figure 5-8 further highlights the data elements of the system.

The Input

The first activity associated with the information system is acquiring the data that will assist the decision-making process. After carefully identifying those data items needed for planning and operating the logistics system, the data can be

Figure 5-7
Operating Components of the Logistics Information System



obtained from many sources, notably, (1) customers, (2) company records, (3) published data, and (4) management. Customers, through their sales activity, indirectly provide much useful data for planning. During order entry, data are captured that are useful for forecasting and operating decisions, such as sales volume, and its timing, location of sales, and order size. Similarly, data about shipment sizes and transportation costs are obtained from deliveries made to customers. Freight bills, purchase orders, and invoices are additional sources of this type of primary data.

Company records, in the form of accounting reports, status reports, reports from internal and external studies, and various operating reports, provide a wealth of data. Data from these reports are usually not organized in any meaningful way for logistics decision-making purposes. Selected data items are captured by the information system to be manipulated in a later stage.

Published data from external sources represent a unique source of data. Much data are available from federally sponsored research, research sponsored by trade associations, data sharing through the Internet and EDI, and suppliers who will provide valuable data just for the goodwill that such sharing creates. Professional

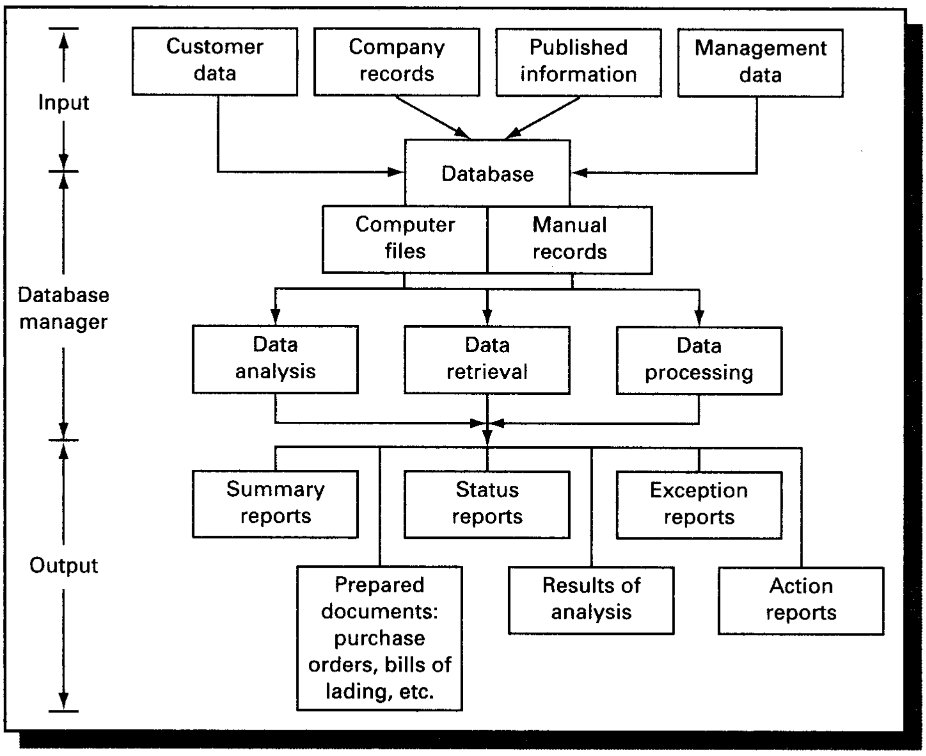


Figure 5-8 Exploded View of the Logistics Information System

journals and trade magazines are additional examples. This type of external data tends to be broader and more generalized than internally generated data.

Company personnel can also be a valuable source of data. Predictions of future sales levels, actions of competition, and the availability of purchased materials are just a few of the examples. These types of data are not so much maintained in company files, computer records, or libraries as they are in the human mind. Company personnel such as management, internal consultants and planners, and activity specialists are close to data sources and become good data sources themselves.

Observation

The computer has brought about new sources of data not previously available and has led to significant improvements in operations. Sears, Roebuck & Co. is a significant retailer of major household appliances, of which it makes nearly 4 million home deliveries annually. Because customers may purchase such goods only every 10 to 15 years, delivery patterns rarely repeat. Historically, Sears' personnel would manually match customer addresses to geocodes. For example, for Ontario, California, the process would take two hours with a 55 percent "hit rate." Using address-matching computer software, the process there now takes 20 minutes with a "hit rate" of over 90 percent.[11]

Database Management

Converting data to information, portraying it in a manner useful for decision making, and interfacing the information with decision-assisting methods are often considered to be at the heart of an information system. Management of the database involves selection of the data to be stored and retrieved, choice of the methods of analysis to include, and choice of the basic data processing procedures to implement.

After determining the content of the database, the first concern in database design is to decide which data should be maintained in traditional hard copy form, the data to be retained in computer memory for quick access, and the data not to be retained on any regular basis. Data maintenance can be expensive and data retention in any form should be based on (1) how critical the information is for decision making; (2) the rapidity of information retrieval; (3) the frequency of data access; and (4) the effort required for manipulating the data into the form needed. Information needed for infrequent strategic planning often does not require immediate access. Information for more frequent operations planning has just the opposite characteristics. A traffic clerk who recalls a freight rate from the computer storage records, or the customer service representative who checks the status of an order through the firm's order-tracking system, takes advantage of these basic storage and online/real-time retrieval capabilities of the information system.

Data processing is one of the oldest and most popular features of an information system. When computers were first introduced into the business community, it was for the purpose of reducing the burdens of computing invoices for thousands of customers and preparing accounting records. Now, preparation of purchase orders, bills of lading, and freight bills is a common data processing activity to aid the logistician in planning and controlling materials flow. Data processing, or transactional, activities represent relatively simple and straightforward conversion of the data in the files to some more useful form. This transactional activity was the dominant feature of the ERP (enterprise resource planning) software systems by SAP, i2, Oracle, and others so popular with companies over the past decade.

Data analysis is the most sophisticated and newest use made of the information system. The system may contain any number of mathematical and statistical models, both general and specific to the firm's particular logistics problems. Such models convert information into problem solutions that provide decision support. Planning picker routing in a high turnover warehouse, routing delivery trucks, and allocating customers to warehouses and plants are examples of decisions that can be assisted by the mathematical tools imbedded within the information system. What started as

[11]"Logistics and Distribution Moves Toward 21st Century," *ARC News*, Vol. 18, No. 2 (Summer 1996), pp. 1–2.

essentially transactional systems, the ERP software systems are now adding decision-support modules to enhance their capabilities.

The Output

The final element of the information system is the output segment. This is the interface with the user of the system. The output is generally of several types and transmitted in several forms. First, the most obvious output is some form of report such as (1) summary reports of cost or performance statistics; (2) status reports of inventories or order progress; (3) exception reports that compare desired performance with actual performance; and (4) reports (purchase orders or production orders) that initiate action. Second, the output may be in the form of prepared documents such as transportation bills of lading and freight bills. Finally, the output may be the result of data analysis from mathematical and statistical models.

The input, a database management capability, and the output are the key features of the internal operation of the LIS. In addition to basic transactional capabilities, the major purpose of the system is to be a decision-support tool for planning and operating the logistics system.

INFORMATION SYSTEM EXAMPLES

In practice, information systems to assist supply chain planning and operation appear within companies in a number of ways. Several examples will help to illustrate them.

A Retail System

Some firms with extensive retail operations have developed elaborate information systems to speed checkout (improve customer service) as well as to increase the efficiency of stocking and replenishing the many items typically offered customers (lower costs). The high transaction volume routinely handled and the high inventory turnover that retailers like to achieve has led them to use computers and the latest order-handling technology to realize their goals.

Application

A major retailer of general merchandise sells through nearly 1,000 stores. The logistics system alone involves 200,000 items flowing from over 20,000 suppliers. The company strategy is to make every store a profit center. This means that stocking decisions from over 40,000 merchandising departments need to be made at the store level. At the same time, purchasing is centralized.

The information system designed to support this decentralized management philosophy involved installing registers in stores with optical scanning capability to read bar codes on merchandise tickets. With minicomputers at stores and mainframe computers at more centralized locations, store sales activity can be captured instantly. The system offers a number of benefits including faster checkouts, more

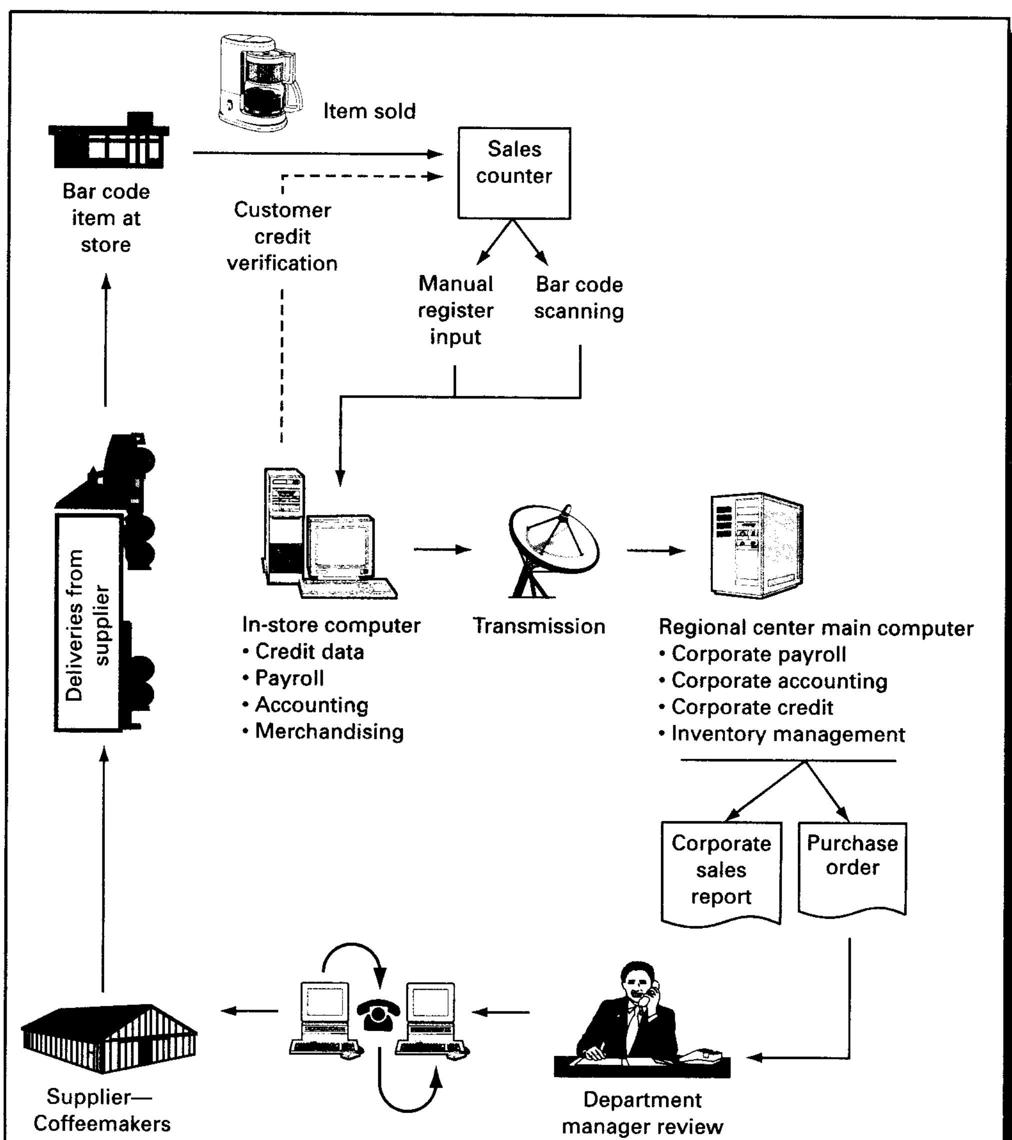


Figure 5-9 Information System for a Large Merchandise Retailer

optimal inventory control, faster credit checking, instant stock status reporting, and better planning of purchase quantities and their timing.

The operation of the system is schematically diagrammed in Figure 5-9. The first step is receipt of the product from the warehouse or supplier. Suppose that the product is a coffeemaker. An automatic ticket maker produces a ticket that indicates the coffeemaker's color, price, stock number, and the clerk's department number.

When a customer takes the coffeemaker to the register, the clerk scans the ticket with a reading wand or keys product information into the register.

If the customer wants to pay with a credit card, the wand picks up a magnetic code and, in less than a second, clears the card through the store's minicomputer. The coffeemaker's data are stored in the minicomputer until the end of the business day. Then, they are automatically transferred to one of the company's 22 regional data centers, where larger mainframe computers process the information. There, the customer's credit account is charged, sales and tax figures are entered into the accounting department's records, and the sales clerk's commission record is sent to the payroll department.

Sales data also enter the coffeemaker department's inventory-management system. If the day's coffeemaker sales lower the department's inventory below a predetermined point, the computer automatically prints a purchase order, which is sent to the department manager the next morning. If the manager decides to buy more coffeemakers, the reorder goes by EDI to the supplier who fills it.

At the same time, the sales data are channeled through the regional data center to a central data processing station at company headquarters, where national unit-sale information is compiled.

Vendor-Managed Inventory

When retailers managed inventory, one of the methods for inventory control was to use some form of a trigger-point method replenishment program. That is, when an item in stock is depleted to the level of the trigger-point quantity, a purchase order is placed on a vendor to replenish the item. In such systems, retailers make their own forecasts and inventory-control rules. Alternately, retailers will replenish on a fixed cycle (e.g., once per week) and order an amount to fill designated shelf space for an item. According to the International Mass Retail Association, over 60 percent of hard goods and almost 40 percent of soft goods are under replenishment programs managed by retailers.[12]

Although retailer-managed replenishment programs are expected to continue, there is also expected to be a substantial growth in vendor-managed inventories (VMI), that is, continuous replenishment. With electronic data interchange and point-of-sale data, vendors can be as aware of what is on the retailer's shelf as the retailer itself. Retailers such as Wal-Mart and Toys "Я" Us allow the vendors to be in charge of their own inventory, deciding what and when to ship. Ownership of the inventory generally shifts to the retailer once the product is received, although some retailers would like to reach the point where they don't even own the goods sitting on their shelves. The increased availability of information is permitting new alternatives for managing the flow of goods in the supply channel to emerge.

Vendors require that their customers supply them with information about product sales, current inventory levels, dates for receipt of goods, and dead stock and

[12]Tom Andel, "Manage Inventory, Own Information," *Transportation and Distribution* (May 1996), p. 58.

returns. Information flows to the vendor through an EDI or other electronic network so that it is up-to-date at all times. Vendors sometimes incur greater costs for VMI, for example, by absorbing the transportation costs, but feel that the additional costs are covered by increased sales that are realized from the use of VMI.

Application

Western Publishing is making VMI work in its Golden Book lines. Western, a publisher of children's books, develops a relationship with its retailers in which these retailers give Western point-of-sale data. The point-of-sale information provides the publisher with the remaining inventory at the retailer that is then compared with a fixed reorder point quantity. Inventory levels below the reorder point automatically trigger a replenishment order. Ownership of the inventory shifts to the retailer once the product is shipped. The sharing of point-of-sale information is the key to making continuous replenishment work in a timely and efficient manner.

In India, oil companies such as IndianOil and Bharat Petroleum Corporation Limited (BPCL) replenish their stocks themselves in their contractual supplies to most of the chemical units. Companies like Maruti Udyog Limited, Ford, and Toyota too have implemented the VMI system for certain categories of stock-keeping units (SKUs).

E-Commerce

For many companies, e-commerce, which uses the Internet to facilitate business transactions, is an extension of the traditional way warehouses and retail stores conduct business. In contrast to start-up Web companies, which typically own no logistics infrastructure and ship directly from vendors using for-hire transportation, established companies have inventories, warehouse space, transportation capabilities, and logistics expertise. With the addition of a Web site for entering customer orders, established companies may append and integrate Web orders with their existing logistics operations. Others may separate the Web order operations from internal operations and even seek outside support of a third-party logistics provider, arguing that the customer requirements are sufficiently different to warrant such a separation. However, we can expect to see that whether orders enter through a Web site or through the sales desk, serving them logistically will not show the marked differences as seen in the past, when e-commerce was new and novel.

Application

Lowe's, the large do-it-yourself home improvement retailer, turned to NFI Interactive as a third-party provider to service its online customers when it began offering its products through the Internet. NFI uses the warehouse management system (WMS) software of All Points Systems to run operations for Lowe's in its 425,000-square-foot Atlanta, Georgia, warehouse, 205,000 square feet of which is being utilized by Lowe's.

Every 15 or 20 minutes, orders from the Web site are downloaded to the WMS. An inventory reserve is put on the ordered items until the customer's credit is verified. From there, the system chooses a parcel delivery method (FedEx, UPS, less-than-truckload, etc.) and orders are released to workers on the warehouse floor.

Product is scanned into and out of inventory using handheld and vehicle-mounted computers. Warehouse order picking is organized according to wave, postal code, order size, and ship-by date or time. Once orders are packed, boxes are conveyed to the Quantronix CubiScan system for sizing and weighing. Then, the appropriate shipping label is generated using Zebra Technologies' printers, and the goods head for their final destination.[13]

Gati is one of the leaders in India in the express cargo movement, and distribution and SCM solutions.[14] The company has a turnover of Rs. 3,613 million, has 6,400 employees on its rolls, and operates over 2,000 vehicles on the road Gati provides its service in 594 of the 602 districts in India. The company also has a well-structured multi-modal service system and a 6-lakh square feet mechanized warehousing facility. Gati uses its own information technology solution called Gati Enterprise Management System (GEMS), developed in-house for its operations. GEMS was designed and developed over a period of two and half years. GEMS connects over 100 major locations over a wide area network (WAN) through terrestrial leased lines. Gati has also deployed Warehouse Management Software (WMS), which is integrated with GEMS.

A Decision Support System

Dispatching trucks to replenish gasoline supplies at auto service stations is a logistics-planning problem that can be aided by a well-designed information system. Incorporating methods into the information system that can analyze data as well as organize and present it can support the user in making important decisions. Data analysis methods can take the form of optimizing procedures. In the well-designed information system, the user not only can call upon the system to provide an initial answer to the decision problem, but can also interact with the system to provide his or her inputs to realize a more practical solution to the problem than the optimizing procedures alone can offer.

[13]Rick Gurin, "Lowe's Gets to Know Online Distribution," *Frontline Solutions*, Vol. 2, No. 3 (March 2001), p. 46.
[14] Available at http://www.gati.com.

Application

Every day throughout the country, a major oil company makes thousands of gasoline and diesel fuel deliveries. Each day's delivery problem is different as customer mix, volumes, and product mix change. The use of a mathematical programming model to help make the dispatching decisions reduces the number of trucks needed to make deliveries and the total miles traveled by them.

The order information inputs to the TMS are not noteworthy since speed is not critical in this application. Once the order information is received from service stations, the order request information is directed to the regional distribution terminal that will fill the order and deliver it. It is first displayed on a computer screen for the dispatcher. He or she previews the orders and separates those having obvious delivery patterns due to large shipment volumes or special delivery requirements. Next, the remaining orders are submitted to the decision-assisting model within the TMS. The model provides an optimized route and schedule for each order and the truck on which it should travel. Finally, interacting with the displayed routes on the computer screen, the dispatcher reviews the schedule and adjusts it as necessary. The TMS then prepares a printed schedule for each driver.

The Taj Group of Hotels has deployed the revenue optimization (RO) software to earn maximum income from every room. It uses its WAN TajNet that connects the group's major hotels in Mumbai, Kolkata, Chennai, Bangalore, and Hyderabad. It also uses an enterprise resource planning (ERP) solution Project Orion, to centralize its two crucial operations—purchasing and finance. The group also uses a centralized reservation system (CRS) to manage the guests, a property management system (PMS) to handle all the properties, a customer relationship management (CRM) solution that identifies the customers' needs, and a data warehousing system. It installed the RO software in 2004. RO has helped the Taj Group to increase its average room rates (ARRs) from Rs. 5,249 in 2004–2005 to Rs. 7,065 in 2005–2006 in Delhi and from Rs. 7,905 to Rs. 10,639 in Bangalore. With RO, Taj's gross revenue increased by 25 percent to Rs. 873.24 crore in 2004–2005 from Rs. 699.16 crore in 2003–2004.[15]

Concluding Comments

Recall that the order cycle can be defined as the time elapsed between the point when the customer prepares an order to the point when the order is received. Order-processing activities can represent most of the time in the customer's total order cycle time. Therefore, managing the activities of the order-processing component of the total order cycle is critical to the level of customer service to be achieved. This is perhaps even more essential, considering customers' continuing desire to compress total order cycle time.

The five key elements of order processing include (1) order preparation; (2) order transmittal; (3) order entry; (4) order filling; and (5) order status reporting.

[15] *CIO* (May 1, 2006), p. 44.

The first three elements have been particularly subject to technological improvements, including bar code scanning, computerized order handling, and electronic communication. For firms using such technology, order preparation, transmittal, and entry can be reduced to almost an insignificant portion of the total order cycle time.

The logistics information system may be decomposed into the order management system (OMS), the warehouse management system (WMS), and the transportation management system (TMS). The transactions and planning decisions associated with each are generally supported with significant computer software programs that greatly assist in making the repetitive decisions required of daily operations. The OMS, WMS, and TMS, while focusing on different aspects of logistics operations, communicate with each other for better overall control of logistics processes. To the extent that timely information for logistics managers will continue to replace assets in the business, we can expect an expanding scope and increasing sophistication in the design of information systems. Logistics information systems show the benefits of the information technology revolution.

QUESTIONS

1. A manufacturer of men's and women's sportswear will distribute its Hong Kong–made products to markets in the United States and Europe. The primary outlets will be small retail stores and some department stores. Suggest several designs for handling order processing. What might be the relative costs and benefits of each?
2. What benefits are there to using bar codes and scanners for order entry as opposed to keyboard encoding into a computer database? Are there any disadvantages?
3. Review the Samson-Packard Company example given beginning on page 137, and suggest how you might compress the order processing time through the sequencing of the activities and the use of technology.
4. In the following situations, indicate the effect on order processing time of (1) processing priorities; (2) parallel versus sequential processing; (3) order-filling accuracy; (4) order batching; and (5) shipment consolidation:
   a. Patients seeking services at a medical clinic
   b. Purchasing sheet steel from a steel manufacturer for use in auto body manufacture
   c. Customers waiting in lunchtime lines at McDonald's restaurants
   d. A supermarket placing stock replenishment orders to their supplying warehouses
5. A logistics manager for a television producer in South Korea has been given the responsibility for setting up a logistics information system for his company. How would you answer his questions below?
   a. What types of information do I want from the information system? Where would I obtain the information?
   b. Which items in the information database should I retain in the computer for easy access? How should I handle the remainder?

c. What types of decision problems would the information system help me address?
d. What models for data analysis would be most useful in dealing with these problems?

6. For the following companies, suggest the types of data that should be collected to plan and control their supply chains:
   a. A hospital
   b. A city government
   c. A tire manufacturer
   d. A retailer of general merchandise
   e. An ore-mining company

   For each of these, what tools for information analysis do you think should be included in the logistics information system?
7. A toy manufacturer is planning a vendor-managed inventory program with one of its retailers, Toys "Я" Us. To operate such a program, what information should the retailer provide to the toy manufacturer? Describe how each information element will be used.
8. Discuss the impact that order-processing priority rules can have on total order-processing time. Under what circumstances would you prefer to process orders according to the first-received, first-processed versus shortest processing time rule?
9. Suppose that you work for a company that sells automotive repair parts and are put in charge of developing an e-commerce strategy for the firm. A Web site is prepared to promote and provide information about the product line, and to accept orders online. How will you plan for order fulfillment, that is, order processing, inventory management, warehousing, shipment preparation, and delivery? What information systems technology might be useful for carrying out these activities?
10. The OMS, WMS, and TMS make up a logistics information system (LIS).
    a. Describe the data elements and decision-support tools that should be in the LIS for (i) a fast food retailer such as Burger King or Pizza Hut, (ii) an auto manufacturer such as General Motors, Toyota, or Fiat, and (iii) a service organization such as the Red Cross.
    b. To form an integrated LIS, what types of data should be shared among the OMS, WMS, and TMS to form an effective logistics information system?
11. A manufacturer of digital cameras and other photographic equipment sells these items through a network of retailers. Several plants located around the world produce the products that are shipped to warehouses, where the products are held as inventory used to supply the retailers. Products are scheduled to go to production based on orders from the warehouses. Warehouses stock products based on anticipated orders from retailers. Retailers reorder for their in-store inventories based on the sales forecasts for their local territories. Trucking is used to move products throughout the supply channel (plant-warehouse-retail store). Uncertainties in the supply channel result from missed forecasts, transport delays, changed production schedules, unanticipated product promotions, and inaccurate inventory counts.

Using the Internet and the company's Web site, design an ordering system that is an alternative to the current ordering approach. Suggest the type of information that each channel member should supply, how ordering decisions should be made, how uncertainties are to be handled, and what the overall advantages might be to Web-based ordering compared with the current ordering system.

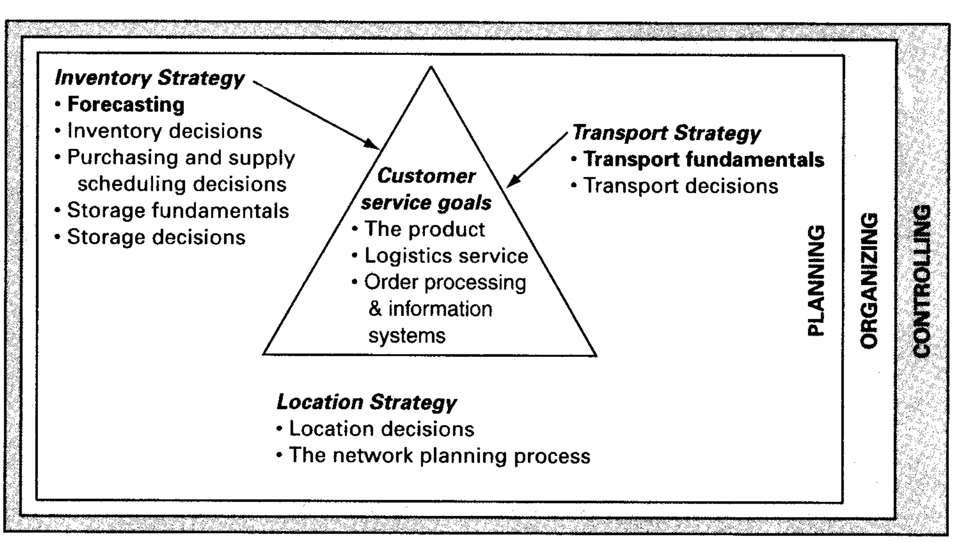
Chapter 6

Transport Fundamentals

When the Chinese write the word crisis, they do so in two characters—one meaning danger, the other opportunity.

—ANONYMOUS

Transportation usually represents the most important single element in logistics costs for most firms. Freight movement has been observed to absorb between one-third and two-thirds of total logistics costs.[1] Thus, the logistician needs a good understanding of transportation matters. Although a comprehensive discussion of transportation is not possible



[1]Recall Table 1-3 on page 14.

within the scope of this text, this chapter highlights what is essential to the logistician for his or her managerial purposes.

The focus is on the facilities and services that make up the transportation system and on the rates (costs) and performance of the various transport services that a manager might select. Specifically, we wish to examine the characteristics of the transportation service alternatives that lead to optimal performance. It is performance that the user buys from the transportation system.

IMPORTANCE OF AN EFFECTIVE TRANSPORTATION SYSTEM

One needs only to contrast the economies of a "developed" nation with those of a "developing" one to see the part that transportation plays in creating a high level of economic activity. It is typical in the developing nation that production and consumption take place in close proximity, much of the labor force is engaged in agricultural production, and a low proportion of the total population lives in urban areas. With the advent of inexpensive and readily available transportation services, the entire structure of the economy changes toward that of developed nations. Large cities result from the migration of the population to urban centers, geographical areas limit production to a narrow range of products, and the economic standard of living for the average citizen usually rises. More specifically, an efficient and inexpensive transportation system contributes to greater competition in the marketplace, greater economies of scale in production, and reduced prices for goods.

Greater Competition

With a poorly developed transportation system, the extent of the market is limited to the areas immediately surrounding the point of production. Unless production costs are extremely low compared with those at a second production point—that is, the production cost difference offsets the transportation costs of serving the second market—not much competition is likely to take place. However, with improvements in the transportation system, the landed costs for products in distant markets can be competitive with other products selling in the same markets.

In addition to encouraging direct competition, inexpensive, high-quality transportation also encourages an indirect form of competition by making goods available to a market that normally could not withstand the cost of transportation. Sales can actually be increased through market penetration normally unavailable to certain products. The goods from outside a region have a stabilizing effect on prices of all similar goods in the marketplace.

Application

In many markets, fresh fruits, vegetables, and other perishable products can be available at only certain times of the year due to seasonal growing patterns and lack of good growing conditions. Yet, many such products are in season at any time during the year somewhere in the world. Rapid shipment at reasonable prices places these perishable products in markets that would not otherwise have the products available. Bananas from South America are available in New York in January, live New England lobsters are served in Kansas City restaurants throughout the year, and Hawaiian orchids are plentiful in the eastern United States in April. An efficient and effective transportation system makes this possible.

Economies of Scale

Wider markets can result in lower production costs. With the greater volume provided in these markets, more intense utilization can be made of production facilities and specialization of labor usually follows. In addition, inexpensive transportation also permits decoupling of markets and production sites. This provides a degree of freedom in selecting production sites so that production can be located where there is a geographic advantage.

Observation

Auto parts manufactured in such places as Taiwan, Indonesia, South Korea, and Mexico are used in assembly operations in the United States and are sold in the U.S. marketplace. Low labor costs and high-quality production are the attractions to manufacture in these foreign locations. However, without inexpensive and reliable transportation, the cost of placing parts throughout the United States would be too high to compete with domestic production.

Reduced Prices

Inexpensive transportation also contributes to reduced product prices. This occurs not only because of the increased competition in the marketplace but also because transportation is a component cost along with production, selling, and other distribution costs that make up the aggregate product cost. As transportation becomes more efficient, as well as offering improved performance, society benefits through a higher standard of living.

Observation

Crude oil can be obtained from domestic sources or it can be imported. Oil reserves in the Middle East are more accessible than they are domestically, and oil can be produced at a lower cost. With the use of large supertankers, oil can be transported to markets around the world and sold at lower prices than locally produced crude oil, if it is available at all.

Service Choices and Their Characteristics

The user of transportation has a wide range of services at his or her disposal that revolve around the five basic modes: water, rail, truck, air, and pipeline. A transport service is a set of performance characteristics purchased at a given price. The variety of transport services is almost limitless. The five modes may be used in combination (e.g., piggyback or container movement); transportation agencies, shippers' associations, and brokers may be used to facilitate these services; small-shipment carriers (e.g., Federal Express, DHL and United Parcel Service) may be used for their efficiency in handling small packages; or a single transportation mode may be used exclusively. From among these service choices, the user selects a service or combination of services that provides the best balance between the quality of service offered and the cost of that service. The task of service-choice selection is not as forbidding as it first appears, because the circumstances surrounding a particular shipping situation often reduce the choice to only a few reasonable possibilities.

To aid in solving the problem of transportation service choice, transportation service may be viewed in terms of characteristics that are basic to all services: price, average transit time, transit time variability, and loss and damage. These factors seem to be the most important to decision makers (recall Table 4-2), as numerous studies over the years have revealed.[2] It is presumed that the service is available and can be supplied with a frequency that makes it attractive as a possible service choice.

Price

Price (cost) of transport service to a shipper is simply the line-haul rate for transporting goods and any accessorial or terminal charges for additional service provided. In the case of for-hire service, the rate charged for the movement of goods between two points plus any additional charges, such as for pickup at origin, delivery at destination, insurance, or preparing the goods for shipment, makes up the total cost of service. When the shipper owns the service (e.g., a fleet of trucks), the cost of service is an allocation of the relevant costs to a particular shipment. Relevant costs include items such as fuel, labor, maintenance, depreciation of equipment, and administrative costs.

Cost of service varies greatly from one type of transport service to another. Table 6-1 gives the approximate cost per ton-mile for the five modes of transportation. Notice that airfreight is the most expensive, and pipe and water carriage are the least costly. Trucking is about seven times more expensive than rail, and rail is about four times as expensive as water or pipeline movement. These figures are averages that result from the ratio of freight revenue generated by a mode to the total

[2]For results of these studies, see James R. Stock and Bernard J. LaLonde, "The Transportation Mode Decision Revisited," *Transportation Journal* (Winter 1977), p. 56; James E. Piercy and Ronald H. Ballou, "A Performance Evaluation of Freight Transport Modes," *Logistics and Transportation Review*, Vol. 14, No. 2 (1978), pp. 99–115; and Douglas M. Lambert and Thomas C. Harrington, "Establishing Customer Service Strategies Within the Marketing Mix: More Empirical Evidence," *Journal of Business Logistics*, Vol. 10, No. 2 (1989), p. 50.

Table 6-1
Average Freight Ton-Mile Transportation Price by Mode

MODE	PRICE, ¢/TON-MILE[a]
Rail	2.28[b]
Truck	26.19[c]
Water	0.74[d]
Pipe	1.46[e]
Air	61.20[f]

[a]Based on average per ton-mile
[b]Class 1
[c]Less than truckload
[d]Barge
[e]Oil pipeline
[f]Domestic
Source: Rosalyn A. Wilson, *Transportation in America 2000*, 18th ed. (Washington, DC: ENO Transportation Foundation, 2000), p. 19.

ton-miles shipped. While these average costs may be used for general comparisons, cost comparisons for the purpose of transport service selection should be made based on actual charges that reflect the commodity being shipped, the distance and direction of the movement, and any special handling required.

Transit Time and Variability

Repeated surveys have shown (recall Table 4-1) that average delivery time and delivery time variability rank at the top of the lists as important transportation performance characteristics. Delivery (transit) time is usually referred to as the average time it takes for a shipment to move from its point of origin to its destination. The different modes of transportation vary according to whether or not they provide direct connection between the origin and destination points. For example, shipments move on air carriers between airports or on water carriers between seaports. However, for purposes of comparing carrier performance, it is best to measure transit time door-to-door, even if more than one mode is involved. Although the major movement of a shipment may be by rail, local pickup and delivery are often made by truck if no rail sidings are available at the shipment origin and destination points.

Variability refers to the usual differences that occur between shipments by various modes. All shipments having the same origin and destination points and moving on the same mode are not necessarily in transit for the same length of time due to the effects of weather, traffic congestion, number of stop offs, and differences in time to consolidate shipments. Transit time variability is a measure of the uncertainty in carrier performance.

Statistics on carrier performance are not extensive, as no one business utilizes the total transportation system enough to provide worthwhile comparisons on a large scale. However, the military and government agencies use the domestic transportation system extensively for all kinds of commodity movements and maintain good records on delivery times. Where the data are available, selective cross-checking

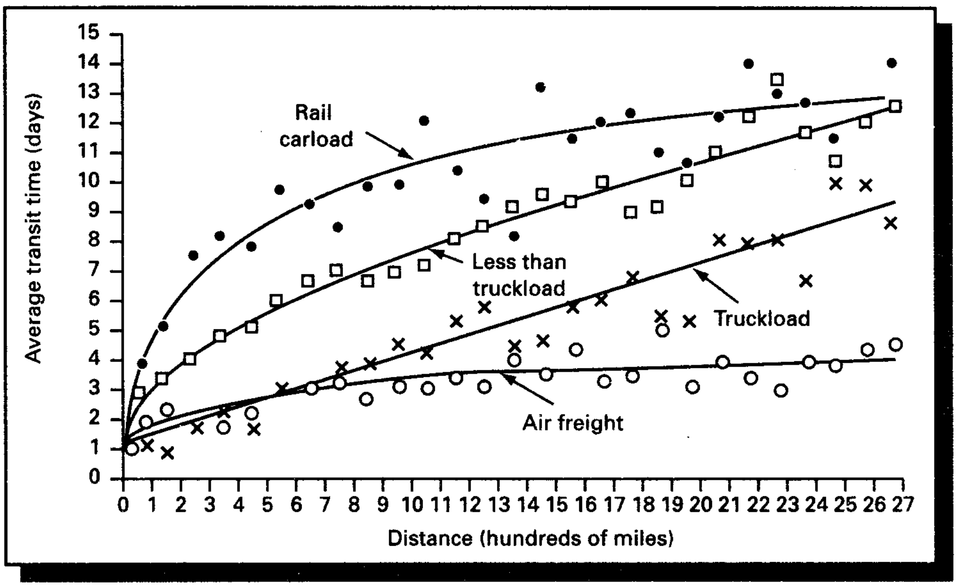


Figure 6-1 Average Transit-Time Experience for Approximately 16,000 Military and Industrial Shipments by Selected Transport Service

Source: James Piercy, "A Performance Profile of Several Transportation Freight Services," (Ph.D. diss., Case Western Reserve University unpublished, 1977).

against industrial shipments shows no significant differences between the data sources with regard to transit time variability.

One of the most extensive studies of carrier performance was carried out on more than 16,000 military and industrial shipments. Some of the results are summarized in Table 6-2 and Figure 6-1. Particularly note that over long distances, rail and air shipments approach constant average transit times, whereas truck transit times continue to increase. Of course, on the average, airfreight is the fastest mode for distances of more than 600 miles, with truckload, less than truckload, and rail following, respectively. For distances less than 600 miles, air and truck are comparable. For very short distances of less than 50 miles, the transit time is influenced more by the pickup and delivery operation than the line-haul transit time.

In terms of variability, the transport services can be roughly ranked as they were for average delivery time. That is, rail has the highest delivery time variability and air has the lowest, with truck service falling between these extremes. If variability is viewed relative to the average transit time for the transport service, air can be the least dependable and truckload the most dependable.

Loss and Damage

Because carriers differ in their ability to move freight without loss and damage, loss and damage experience becomes a factor in selecting a carrier. Product condition is a primary customer service consideration.

Table 6-2 A Comparison of Average Transit Time and Time Range for 95% of Shipments in Days by Various Transport Services for Selected Mileages

	Railcarload		Less Than Truckload		Truckload		Airfreight		Air Express		Piggyback[a]	
Selected Mileages	Avg.	95% Range	Avg.	95% Range	Avg.	95% Range	Avg.	95% Range	Avg.	95% Range	Avg.	95% Range
0–49	1.5	0[b]–3.5	1.7	0–5.1	0.8	0–3.2	—[c]	—[c]	—[c]	—[c]	—[c]	—[c]
100–199	5.2	0–11.9	3.4	0–7.7	2.0	0–5.6	2.3	0–7.7	1.9	0–5.1	3.8	0–7.4
300–399	8.3	1.4–15.2	5.0	0.4–9.6	1.9	0–4.7	1.8	0–5.9	2.1	0–5.7	4.4	1.7–7.1
500–599	9.8	2.5–17.1	6.0	0–12.0	2.7	0–6.4	3.1	1.1–6.0	1.6	0–4.1	6.6	0–13.7
700–799	8.6	0.6–16.6	7.1	0–14.5	4.1	0–8.9	3.2	0.1–6.3	2.3	0–6.1	6.2	1.0–11.4
1000–1099	12.2	2.9–21.5	7.4	1.3–13.5	4.0	1.1–6.9	3.0	0.2–5.9	1.4	0–3.7	6.1	1.5–10.7
1500–1599	11.1	5.6–16.6	8.9	0.7–17.2	5.3	0.8–9.9	4.6	0.7–9.9	1.5	0–4.9	4.6[d]	0–10.0[d]
2000–2099	11.5	1.4–21.5	11.1	3.2–18.9	8.0	0–16.1	4.0	0–9.0	1.8	0–4.6	5.1[d]	2.6–7.7[d]
2500–2599	12.4	8.3–16.6	12.3	6.7–17.9	8.8	3.3–14.3	4.4	0–10.1	3.4	0–9.6	6.7[d]	1.1–12.2[d]
3000–3099	10.6	1.5–19.7	12.9	3.8–22.0	10.4	5.9–14.9	3.2	0.7–7.0	6.0	0–23.3	5.6[d]	3.9–7.3[d]

[a]Trailer on flatcar
[b]Zero refers to shipment deliveries made in less than one day.
[c]Insufficient data
[d]DeHayes' data
Source: Adapted from James Piercy, "A Performance Profile of Several Transportation Freight Services," (Ph.D. diss., Case Western Reserve University unpublished, 1977); and Daniel DeHayes, Jr., "The General Nature of Transit Time Performance of Selected Transportation Modes in the Movement of Freight," (Ph.D. diss., Ohio State University, 1968): pp. 163–177.

Common carriers have an obligation to move freight with reasonable dispatch and to do so using reasonable care in order to avoid loss and damage. This responsibility is relieved if loss and damage result from an act of God, default by the shipper, or other causes not within control of the carrier. Although carriers, upon proper presentation of the facts by the shipper, incur the direct loss sustained by the shipper, there are certain imputed costs that the shipper should recognize before making a carrier selection.

Potentially the most serious loss that the shipper may sustain has to do with customer service. The shipment of goods may be for replenishing a customer's inventory or for immediate use. Delayed shipments or goods arriving in unusable condition means inconvenience for the customer or possibly higher inventory costs arising from a greater number of stockouts or back orders when anticipated replenishment stocks are not received as planned. The claims process takes time to gather pertinent facts about the claim, takes effort on the part of the shipper to prepare the proper claim form, ties up capital while claims are being processed, and sometimes involves a considerable expense if the claim can be resolved only through court action. Obviously, the fewer the claims against a carrier, the more favorable the service appears to the user. A common reaction of shippers to a high likelihood of damage is to provide increased protective packaging. This expense must ultimately be borne by the user as well.

SINGLE-SERVICE CHOICES

Each of the five basic transportation modes offers its services directly to users. This is in contrast to the use of a "transportation middleman," such as a freight forwarder, who sells transportation services but usually owns little or no line-haul movement capability. Single-mode service is also in contrast to those services involving two or more individual transportation modes.

Rail

The railroad is a long hauler and slow mover of raw materials (coal, lumber, and chemicals) and of low-valued manufactured products (food, paper, and wood products) and prefers to move shipment sizes of at least a full carload. In 1999, the average length of haul was 712 miles,[3] with an average train speed of 20 miles per hour.[4] Average car distance traveled was 64 miles per day in line-haul service.[5] This relatively slow speed and short car distance traveled in a day reflect the fact that the majority (86 percent) of freight car time is spent in loading and unloading operations, moving from place to place within terminals, classifying and assembling cars into trains, or standing idle during a seasonal slump in car demand.

[3]Rosalyn A. Wilson, *Transportation in America 2000*, 18th ed. (Washington, DC: ENO Transportation Foundation, 2000), p. 51.
[4]*Statistical Abstract of the U.S.: 2000*, p. 695.
[5]*Statistical Abstract of the U.S.: 1989*, p. 606.

Rail service exists in two legal forms, common carrier or privately owned. A common carrier sells its transportation services to all shippers and it is guided by the economic[6] and safety regulations of the appropriate government agencies. In contrast, private carriers are shipper owned with the usual intent of serving only the owner. Because of the limited scope of the private carrier's operations, no economic regulation is needed. Nearly all rail movement is of the common carrier type.

Common carrier line-haul rail service is primarily carload (CL). A carload quantity refers to a predetermined shipment size, usually approaching or exceeding the average capacity of a railcar to which a particular rate is applied. A multiple-carload quantity rate per hundredweight (cwt.) may be offered and is less than the less-than-carload (LCL) rate, which reflects the reduced handling time required for high-volume shipments. Nearly all rail freight today moves in carload quantities, a reflection of the trend toward volume movement. Larger freight cars are being used with an average freight car capacity of 83 tons, and single-commodity trains (called unit trains) of 100 or more cars per train are being used with rate reductions of 25 to 40 percent over single carloads.

Railroads offer a diversity of special services to the shipper, ranging from the movement of bulk commodities such as coal and grain to special cars for refrigerated products and new automobiles which require special equipment. Other offerings include expedited service to guarantee arrival within a certain number of hours; various stop-off privileges, which permit partial loading and unloading between origin and destination points; pickup and delivery; and diversion and reconsignment, which allow circuitous routing and changes in the final destination of a shipment while en route.

Indian Railways (IR) is the second largest rail network in the world covering about 63,465 route kilometers.[7] It transports about 667 million tonnes of cargo every year with the freight segment accounting for two-thirds of revenues. The freight movement of IR has risen to 411,354 net tonne-kilometers. About 50 percent of the bulk traffic comprises coal. IR runs about 16,021 trains everyday. The turnaround time of wagons has reduced from 7 to 5.5 days. The Railway Budget for 2006–2007 has proposed an investment of Rs. 220 billion for the first phase of constructing a dedicated multimodal high-axle load freight corridor. The corridor will have computerized control in the western and eastern routes adding about 10,000 kilometers to the existing rail network. Besides, the railway ministry is offering a 20-percent discount on freight when the train returns back to its point of origin.

Truck

In contrast with rail, trucking is a transportation service of semifinished and finished products with an average length of freight haul of 717 miles for less than truckload (LTL) and 286 miles for truckload (TL).[8] In addition, trucking moves freight with

[6]Little federal economic regulation remains since the passing of the Staggers Rail Act of 1980, which economically deregulated rail transportation. Some regulation remains at the state level.
[7]Available at http://www.indianrail.gov.in.
[8]*Transportation in America 2000*, p. 51.

smaller average shipment sizes than rail. More than half of the shipments by truck are less than 10,000 pounds, or LTL volume. The inherent advantages of trucking are its door-to-door service, involving no loading or unloading between origin and destination, as is often true of rail and air modes; its frequency and availability of service; and its door-to-door speed and convenience.

Truck and rail services show some distinct differences, even though they compete for many of the same product shipments. First, in addition to the common and private legal classification of carriers, trucking offers services as contract carriers as well. Contract carriers do not hire themselves out to service all shippers as do common carriers. Shippers enter into a contractual arrangement to obtain a service that better meets their particular needs without incurring the capital expense and administrative problems associated with private ownership of a trucking fleet.

Second, trucks can be judged less capable of handling all types of freight than rail, mainly due to highway safety restrictions that limit the dimensions and weight of shipments. Most shipments must be shorter than the popular 40- to 53-foot trailer (unless a double or triple bottom) and less than 8 feet wide and 8 feet tall to ensure road clearance. Specially designed equipment can accept loads in different dimensions than these.

Third, trucking offers reasonably fast and dependable delivery for LTL shipments. The trucker needs to fill only one trailer before moving the shipment, whereas a railroad must be concerned with making up a train length of 50 cars or more. On balance, trucking has a service advantage in the small-shipment market.

The size of the Indian road freight transport sector is estimated at $10 billion, in which the majority (close to 80 percent) is unorganized and extremely fragmented. Trucking accounts for nearly 70 percent of transportation and 60 percent of all logistics cost. 67 percent of truck ownership is in the hands of small unorganized players. There are 27 lakh commercial fleet, owned by over 5 lakh fleet operators. The industry operates through brokers who arrange load for small fleet owners from shippers. Small regional operators dominate the existing road freight industry.[9]

Road freight has outperformed rail freight in the last five years despite rising fuel costs and belying reports of IR making inroads into road freight. Goods freight in IR grew by more than 35.51 percent while roadways fared better with a freight growth of over 48.32 percent. Total freight movement on the railways increased from 492.50 million tonnes in 2001–2002 to 667.39 million tonnes in 2005–2006, while freight movement on the roadways grew from 1,553.60 million tonnes to 2,304.32 million tonnes. In the first quarter of 2006–2007 also, this trend has continued.[10]

Air

Air transportation is being considered by increasing numbers of shippers for regular service, even though airfreight rates exceed those of trucking by more than two times and those of rail by more than 16 times. The appeal of air transportation is its

[9]Samir K. Srivastava, "Logistics and Supply Chain Practices in India," *Vision: The Journal of Business Perspective*, Vol. 10, No. 3 (2006), pp. 69–79.

[10]*The Indian Express* (August 16, 2006), p. 13..

unmatched origin-destination speed, especially over long distances. The average length of a freight haul is 1,001 miles.[11] Commercial jets have cruising speeds between 545 and 585 miles per hour, although airport-to-airport average speed is somewhat less than cruising speed because of taxi and holding time at each airport and the time needed to ascend to and descend from cruising altitude. But this speed is not directly comparable with that of other modes because the times for pickup and delivery and for ground handling are not included. All these time elements must be combined to represent door-to-door air delivery time. Because surface freight handling and movement are the slowest elements of total door-to-door delivery time, overall delivery time may be so reduced that a well-managed truck and rail operation can match the schedule of air. Of course, this depends on individual cases.

Air-service dependability and availability can be rated as good under normal operating conditions. Delivery-time variability is low in absolute magnitude, even though air service is quite sensitive to mechanical breakdown, weather conditions, and traffic congestion. Variability, when compared with average delivery times, can rank air as one of the least reliable modes.

The capability of air has been greatly constrained by the physical dimensions of the cargo space in the aircraft and the aircraft's lifting capacity. This is becoming less of a constraint, however, as larger aircraft are put into service. For example, "jumbo" airplanes such as the Boeing 747 and Lockheed 500 (commercial version of the military's C5A) handle cargo of 125 to 150 tons. Door-to-door ton-mile costs are expected to drop to about one-half of the current cost levels through the benefits of new technology, deregulation, and productivity-improvement programs. This would make air a serious competitor with the more premium forms of surface-transport services.

Air transportation has a distinct advantage in terms of loss and damage. According to a classic study by Lewis, Culliton, and Steele,[12] the ratio of claim costs to freight revenue was only about 60 percent of those for truck or rail. In general, less protective packaging is required for airfreight, if ground handling does not offer a higher exposure to damage than the en route phase of the movement and airport theft is not excessive.

Air transportation service exists in common, contract, and private legal forms. Direct air service is offered in seven types: (1) regular domestic truck-line carriers; (2) all-cargo carriers; (3) local-service airlines; (4) supplemental carriers; (5) air taxis; (6) commuter airlines; and (7) international carriers. About a dozen airlines operate currently over the most heavily traveled routes. These airlines offer cargo-carrying services in addition to their regularly scheduled passenger operations. All cargo carriers are common carriers of freight only. Service is concentrated at night, and rates average 30 percent less than those for domestic trunk-line carriers. Local-service airlines provide a "connecting" service with domestic trunk-line carriers for less populated centers. They provide both cargo and passenger service. Supplemental (charter) carriers operate much as do trunk-line carriers, except that they do not have regular schedules. Commuter airlines are like local-service carriers that "fill in" routes

[11]Ibid.

[12]Howard T. Lewis, James W. Culliton, and Jack W. Steele, *The Role of Air Freight in Physical Distribution* (Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1956), p. 82.

abandoned by trunk-line carriers since deregulation. In general, smaller aircraft are operated than those of trunk-line carriers. Air taxis are small aircraft, namely, helicopters and small fixed-wing aircraft, offering a shuttle service for passengers and cargo between downtown areas and airports. They often have only irregular service. International carriers transport freight and passengers beyond their domestic regions.

The aviation industry in India is witnessing major revamp and modernization. Investments are expected to increase with the relaxation on private participation including foreign investors. Three major functions like traffic control, communication, and navigational services and security will continue to remain with the Airport Authority of India. The outstanding investment in the aviation sector as on March 2006 stood at Rs. 25,174 crore covering 86 projects. The Government of India (GoI) will invest Rs. 1,431 crore in 58 projects, mainly to modernize existing airports. The various state governments will execute about 22 projects, costing Rs. 12,549 crore, most of which are new ventures.[13]

Water

Water transportation service is limited in scope for several reasons. Domestic water service is confined to the inland waterway system, which requires shippers to be located on the waterways or to use another transportation mode in combination with water. In addition, water service on the average is slower than rail. The average speed on the Mississippi water system is between five and nine miles per hour, depending on direction. The average length of a freight haul is 481 miles on rivers, 507 miles on the Great Lakes, and 1,648 miles along U.S. coasts.[14] Availability and dependability of water service are greatly influenced by the weather. Movement on the waterways in the northern part of the country during the winter is impossible, and floods and droughts may interrupt service at other times. There is tremendous capacity available in water carriers, with barge tows up to 40,000 tons, and there are individual barges with standardized dimensions 26 by 175 feet and 35 by 195 feet. Capability and handling are being increased as barge-carrying ships are being developed, and such improvements as satellite navigation with radar, refined depth finders, and auto piloting mean around-the-clock service.

Water services are provided in all legal forms, and most commodities shipped by water move free of economic regulation. In addition to unregulated private carriage, liquid cargoes in bulk moving in tank vessels and commodities in bulk such as coal, sand, and grain, which make up over 80 percent of the total annual ton-miles by water, are exempt. Outside of the handling of bulk commodities, water carriers, especially those in foreign service, do move some higher-valued commodities. This freight moves in containers[15] on containerized ships to reduce handling time, to affect intermodal transfer, and to reduce loss and damage.

[13] *Project Monitor* (April 10, 2006), p. 11.
[14] *Transportation in American 2000*, p. 51.
[15] Containers are standardized "boxes," usually 8 × 8 × 10 ft, 8 × 8 × 20 ft, or 8 × 8 × 40 ft, in which freight is handled as a unit and which are easily transferred as a unit to other transportation modes.

Loss and damage costs resulting from transporting by water are considered low relative to other modes because damage is not much of a concern with low-valued bulk products, and losses due to delays are not serious (large inventories are often maintained by buyers). Claims involving transport of high-valued goods, as in ocean freight, are much higher (approximately 4 percent of ocean-ship revenues). Substantial packaging is needed to protect goods, mainly against rough handling during the loading and unloading operations.

The Ganga between Allahabad-Haldia (1,620 kilometers), the Sadiya-Dhubri stretch of river Brahmaputra (891 kilometers), and the Kollam-Kottapuram stretch of West Coast Canal along with Champakara and Udyogmandal Canals (205 kilometers) in Kerala have so far been declared as National Waterways and are being developed for navigation by Inland Waterways Authority of India (IWAI). The cargo movement through these was 29.40 lakh tonnes in 2003–04. The Government of India has drawn up plans to invest Rs. 1,00,339 crore in 387 projects over the next 20 years, under the National Maritime Development Programme (NMDP). The amount includes Rs. 55,804 crore to be invested in public-private-partnership projects to increase the cargo handling capacity of 12 major ports from 397.5 million tonnes per annum (MTPA) to 820 MTPA by 2011–12. NMDP also envisages an investment of Rs. 44,535 crore for the development of shipping and inland water transport systems.[16]

Pipeline

To date, pipeline transportation offers a very limited range of services and capabilities. The most economically feasible products to move by pipeline are crude oil and refined petroleum products. However, there is some experimentation with moving solid products suspended in a liquid, referred to as a "slurry," or containing the solid products in cylinders that in turn move in a liquid within the pipe. If these innovations prove to be economical, pipeline service could be greatly expanded. Early experience with coal suspended in a liquid has not been favorable, because the pipes have eroded.

Product movement by pipeline is very slow, only about three to four miles per hour. This slowness is tempered by the fact that products move 24 hours a day, 7 days a week. This makes the effective speed much greater when compared with other modes. Pipeline capacity is high, considering that a 3-mph flow in a 12-in.-diameter pipe can move 89,000 gallons per hour.

Concerning transit time, pipeline service is the most dependable of all modes, because there are few interruptions to cause transit time variability. Weather is not a significant factor, and pumping equipment is highly reliable. In addition, the availability of pipeline capacity is limited only by the use that other shippers may be making of the facilities at the time capacity is desired.

Product loss and damage for pipelines is low because (1) liquids and gases are not subject to damage to the same degree as manufactured products; and (2) the number of dangers that can befall a pipeline operation is limited. There is liability for such loss and damage when it does occur because pipelines have the status of common carriers, even though many are private carriers in form.

[16]Available at http://iwai.nic.in.

The 1,469 kilometers long Hazira-Bijaipur-Jagdishpur (HBJ) pipeline network is the most noteworthy pipeline in India that carries natural gas (NG) from Gujarat in Western India to Central India. It is maintained by Gas Authority of India Limited (GAIL). Reliance Energy Limited (REL) has approached GAIL for transporting gas for its 4,000-megawatt (MW) power plant being set up at Dadri in Uttar Pradesh. GAIL has offered to transport gas from the Krishna-Godavari (KG) basin to Dadri by using a part of the HBJ pipeline network. REL plans to transport about 20 million standard cubic meters per day (MMSCMD) of natural gas required for the plant by 2008.[17] Earlier, laying of 660 kilometers Numaligarh-Siliguri pipeline for transporting petrol, diesel, and kerosene, produced by Numaligarh Refinery to be laid by Oil India Limited (OIL), was approved by the Cabinet Committee on Economic Affairs, Government of India. This Rs. 468.92 crore pipeline, will transport 1.72 million tonnes of petroleum products from the refinery to Siliguri, and help in uninterrupted evacuation of surplus products.[18] The Indian Oil Corporation Limited too will implement a liquefied petroleum gas (LPG) pipeline from Panipat to Jalandhar. The project will evacuate LPG from the IOC refinery at Panipat and transport it to bottling plants at Nabha and Jalandhar. The project will also establish a pumping station and lay a 275 kilometer pipeline. It will also install a delivery and a terminal station. The cost of the project is estimated at Rs. 185 crore.[19]

Further, Reliance Industries Limited (RIL) is planning to invest Rs. 5,000 crore in the city gas distribution (CGD) project. The company will supply natural gas to households, industries, and automobiles through the CGD network. RIL will set up CGD networks in Visakhapatnam, Kakinada, Vijayawada, Nalgonda, and Hyderabad in Andhra Pradesh and in Sholapur, Pune, and Thane in Maharashtra. The company plans to procure gas from its gas fields in the Bay of Bengal to supply to hotels, restaurants, hospitals, industries, and automobiles in the form of compressed natural gas (CNG). The CGD project will be implemented in 2008–2009. The company's Dhirubhai-1 and Dhirubhai-3 oil discoveries off the Andhra coast will have the capacity to produce 40 MMSCMD from June–July 2008. The company will transport the gas through the Kakinada-Hyderabad-Uran-Ahmedabad pipeline. The company plans to transport 8 MMSCMD of gas every day.[20]

To summarize the quality of the services offered by transportation industry, Table 6-3 shows a ranking of the various modes using the four cost and performance characteristics set forth at the beginning of this section. It should be recognized that under specific circumstances of product type, shipping distance, carrier management, user-carrier relationships, and weather conditions, these rankings may change, and the service of particular modes may not be available.

[17]*Business Standard* (August 24, 2005), p. 6.
[18]*The Asian Age* (September 23, 2005), p. 6.
[19]*Project Alert* (June 19, 2006), p. 12.
[20]*The Corporate Today* (June 30, 2006), p. 30.

Mode of Transportation	Performance Characteristics				
	Cost[b] 1 = Highest	Average Delivery Time[c] 1 = Fastest	Delivery-Time Variability: Absolute 1 = Least	Delivery-Time Variability: Percent[d] 1 = Least	Loss and Damage 1 = Least
Rail	3	3	4	3	5
Truck	2	2	3	2	4
Water	5	5	5	4	2
Pipe	4	4	2	1	1
Air	1	1	1	5	3

[a] Service is assumed to be available
[b] Cost per ton-mile
[c] Door-to-door speed
[d] Ratio of absolute variation in delivery time to average delivery time
Source: Author's estimates for average performance over a variety of circumstances.

Table 6-3 Relative Rankings of Transportation Mode by Cost and Operating Performance Characteristics[a]

Intermodal Services

In recent years, there has been an increase in shipping products using more than one transportation mode in the process. Beyond obvious economic benefits, increased international shipping has been a driving force. The major feature of intermodalism is the free exchange of equipment between modes. For example, the container portion of a truck trailer is carried aboard an airplane, or a railcar is hauled by a water carrier. Such equipment interchange creates transportation services that are not available to a shipper using a single-transportation mode. Coordinated services are usually a compromise between the services individually offered by the cooperating carriers. That is, cost and performance characteristics rank between those of the carriers separately.

There are ten possible intermodal service combinations: (1) rail-truck; (2) rail-water; (3) rail-air; (4) rail-pipeline; (5) truck-air; (6) truck-water; (7) truck-pipeline; (8) water-pipeline; (9) water-air; and (10) air-pipeline. Not all of these combinations are practical. Some that are feasible have gained little acceptance. Only rail-truck, called *piggyback*, has seen widespread use. Truck-water combinations, referred to as *fishyback*, are gaining acceptance, especially in the international movement of high-valued goods. To a much lesser extent, truck-air and rail-water combinations are feasible, but they have seen limited use.

Trailer on Flatcar

Trailer on flatcar (TOFC), or piggyback, refers to transporting truck trailers on railroad flatcars, usually over longer distances than trucks normally haul. TOFC is a blend of the convenience and flexibility of trucking and the long-haul economy of rail. The rate is usually less than for trucking alone and has permitted trucking to extend its economical range. Likewise, rail has been able to share in some traffic that normally would move by truck alone. The shipper benefits from the convenience of door-to-door service over long distances at reasonable rates. These features have made piggyback the most popular coordinated service. The number of railcars loaded with highway trailers and containers has shown a steady and dramatic increase from 554,000 in 1960 to 9,740,000 in 1996 (annualized), or 55 percent of railcar loadings.[21]

Five different plans are offered for TOFC service, depending on who owns the highway equipment and rail equipment and on the rate structure established. These plans are as follows:

- *Plan I.* Railroads transport the trailers of highway common carriers. Billing is through the highway carriers, and the railroads charge a portion of the carriers' rate or a flat fee for moving the trailer.
- *Plan II.* Railroads use their own trailers and containers and transport these on their own flatcars to provide a door-to-door service. Railroads contract with local truckers to handle assembly at originating terminals and delivery from destination terminals. Shippers deal only with railroads and receive rates comparable to those of highway common carriers.
- *Plan II 1/4.* Similar to Plan II, except railroads provide either pickup or delivery, or both.
- *Plan II 1/2.* Railroads provide the trailers or containers and the shippers provide the service of moving these to and from the rail terminals.
- *Plan III.* Shippers or freight forwarders can place their own trailers or containers, empty or loaded, on railroad flatcars for a flat rate. The rate is for ramp-to-ramp; that is, pickup and delivery are the responsibility of the shippers.
- *Plan IV.* Shippers furnish not only the trailers or containers, but also the railroad equipment on which the trailers or containers move. The railroad charges a flat rate for moving the cars, empty or loaded. The payment to the railroad is for the rails and for pulling power.
- *Plan V.* Two or more rail and truck carriers quote jointly on TOFC service. Each carrier may solicit freight for the other, which has the effect of extending the territory of each into that served by the other.

Konkan Railway Corporation Limited (KRCL) introduced Roll-on-Roll-off (Ro-Ro) service in 1999 between Mumbai and Goa. The Ro-Ro service covers 720 kilometers between Kolad and Suratkal in 15–16 hours. The goods are loaded into trucks either at Mumbai or at Mangalore and are brought to Kolad (near Pen, Mumbai) or Suratkal (near Mangalore). The trucks then ride piggyback on train. The service was extended to Mumbai and Mangalore from June 2004. The big savings in fuel and vehicle maintenance costs, apart from the shorter time taken to transport goods on rail, has made KRCL 's Ro-Ro service a big success. KRCL made a maximum of

[21]"Intermodal Traffic Creeps Upward," *Daily Trucking and Transportation News* (July 24, 1996).

14 trips (both ways) in a month and earned Rs. 6.35 crore that year through this service. The commodities that are mainly transported include food grains, timber, glazed tiles, marbles, and black pepper among others. Subsequently, other zones of Indian Railways too have introduced or are in the process of introducing this piggyback service of intermodal transportation.[22] Gujarat Ambuja Cements move significant quantities of cement using silo vessels through water transport.[23]

Containerized Freight

Under a TOFC arrangement, the entire trailer is transported on a railroad flatcar. However, it is also possible to visualize the trailer in two ways, that is, (1) as a container or box in which the freight is packaged; and (2) as the trailer's chassis. In a truck-rail intermodal service, it is possible to haul only the container, thus saving the dead weight of the understructure and wheels. Such a service is called container-on-flatcar (COFC).

The standardized container is a piece of equipment that is transferable to all surface transportation modes with the exception of pipeline. Because containerized freight avoids costly rehandling of small shipment units at the point of intermodal transfer and offers a door-to-door service capability when combined with truck, water carriers use container ships so that combinations of water-truck service can be provided. This type of service is expanding, especially due to the increase in international trade. The container can also be used in combination services with air. The most promising to date is the air-truck combination. The container is important to air transportation because the high movement costs prohibit transporting the chassis of a highway trailer. The use of large containers in air transportation has been limited by the dimensions of the existing aircraft and the small shipment sizes that air transportation predominantly handles, but as air freight rates are reduced, possibly due to larger aircraft being put into service, coordinated air-truck service should expand.

The services of coordinated transportation services will hinge on the container size that is adopted as standard. A container that is too large for trucking or that is incompatible with trucking equipment will exclude trucking from participating. The same argument holds for the other modes. The typical container sizes are 8 by 8 by 20 feet and 8 by 8 by 40 feet. Both are compatible with the standard 40-foot highway trailer and with most other modes.

Observation

Containerized freight movement began in 1956 when Malcom McClean first moved freight in ocean-borne trailers on a World War II tanker that sailed from Newark, New Jersey, to Houston, Texas. Soon after this, a ship was specially converted to stack van-sized boxes on its deck. Containerized service spread from Puerto Rico to

[22]Available at http// www.indianrailways.gov.in.
[23]Available at http//www.gujaratambuja.com.

Europe to the Pacific. McClean's idea cut terminal handling time, stealing, and insurance costs. Now, 75 percent of the U.S. ocean merchandise trade with the rest of the world is hauled in big containers instead of the crates, tubs, sacks, and boxes previously used.[24]

India is rapidly moving into containerization. The containerized freight movement started in November 1989, when Container Corporation of India Limited (CONCOR) started with just seven inland container depots (ICDs). The impetus was provided by Container Transport Logistics Project in 1994 that aimed at providing a suitable enabling environment for Container transport and increased the capacity and efficiency of long haul transport of high-value general cargo, particularly related to foreign trade. The project focused on increasing the use of containers in the transport of general cargo and encouraging and facilitating the use of the railway for such transport wherever it was economically the best option. CONCOR's turnover was Rs. 50 crore in 1991–92 and today it stands at over Rs. 2,440 crore.[25] In fact, the development of multimodal and container traffic as a viable option can be linked to the development of CONCOR till 2006.

Presently, CONCOR is planning to raise its revenue growth from 15–20 percent every year by adding 1,000 wagons. The revenues will increase when the cargo-dedicated railway network, which support faster trains that can run up to 150 kilometer per hour, come up. The company owns 6,000 high-speed container-carrying wagons with 55 ICDS which are connected by rail and road. CONCOR plans to increase its fleet of leased trucks and trailer trucks and build joint ventures with road freight companies. The company has its air cargo business in Hindustan Aeronautics Limited (HAL) airport in Bangalore. It also proposes to begin operations at its integrated freight terminal in Nashik by March 2007. The terminal is a joint venture of CONCOR and HAL. It is an air cargo complex with a 3.1 kilometers long runway. Transport of container cargo from and to the terminal will be by road. CONCOR proposes to build a rail link to the terminal and set up similar terminals at different places.[26]

However, the scene is set to change with private players being allowed into the multimodal business. New entrants into the container transport business have to invest Rs. 35 crore for a single route and Rs. 100 crore for national expansion, which is inclusive of permit for a 20-year period. In January 2006, IR opened up the operation of container freight trains to the private sector.[27] So far, only one company, Pipavav Rail Corporation Limited (PRCL) has sought registration. Many public and private sector units like Reliance, TISCO, SAIL, Hindustan Infrastructure, Transport Corporation of India, JM Bakshi, Maersk, Fedex, United Parcel Service, and Golden Transport may enter the container transport business.[27, 28]

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[24]"McClean Makes Containers Shipshape, 1956," *Wall Street Journal*, November 29, 1989, B1.
[25]Available at http://www.etintelligence.com/etig/productsandservices.
[26]*Financial Express* (August 9, 2006), p. 4.
[27]*The Times Of India*, New Delhi (February 6, 2006), p. 17.
[28]*Business World* (January 23, 2006), p. 42.

Agencies and Small Shipment Services

Agents

Several agencies exist that offer transportation services to shippers but own little or no line-haul equipment. Primarily, they handle numerous small shipments and consolidate them into vehicle-load quantities. Rates competitive with those for LTL are charged, and the agency, through its consolidation of the many small shipments it handles, can obtain vehicle-load rates. The freight-rate differential between large and small shipments helps to offset operating expenses. In addition to consolidation, agencies provide pickup and delivery services to shippers. Transportation agencies include air and surface freight forwarders, shippers' associations, and transport brokers.

Freight forwarders are for-hire carriers of freight. They do own some equipment, but this is mainly for pickup and delivery operations. They purchase long-distance services from air, truck, rail, and water carriers. A major advantage of freight forwarders is that they can quote rates on shipments up to 30,000 pounds, while the average shipment weight handled is only about 300 pounds.

Shippers' associations are cooperative organizations operating on a nonprofit basis. Members belong to the association to realize lower shipping costs. The associations are designed to perform services similar to those of freight forwarders. They act as a single shipper in order to obtain volume rates. Each member shipper pays a portion of the total freight bill, based on the amount to be shipped.

Transport brokers are agents that bring shippers and carriers together by providing timely information about rates, routes, and capabilities. They may arrange for transportation, but assume no liability for it. They are especially valuable to carriers that use brokers to find business for them. Numerous Web sites have emerged that, for a fee, match shippers and carriers for better use of transportation equipment for carriers and lower rates for shippers.

Small-Shipment Services

Parcel post is a small-shipment delivery service offered by United States Postal Service. Shipments are limited in size and may weigh up to 70 pounds and be up to 130 inches in length,[29] and delivery is made to all points in the United States. Rates are based on the distance from the point of shipment origin to the point of delivery. Parcel post uses the service of line-haul carriers. United Parcel Service and Federal Express offer small-package services similar to parcel post, with competitive rates and performance levels. Pickup service is available and deliveries are made in all states and around the world. Premium air small-shipment services also are available that offer overnight and, in some cases, same-day delivery. Federal Express is the most popular service of this type, although UPS and United States Postal Service offer competing services.

[29]Size refers to the sum of the length (longest dimension) and girth (twice the width plus twice the depth). These limits are further reduced for first-class postal service.

In addition to agencies that specialize in small-shipment services, line-haul carriers also move small shipments. There is usually a flat charge when the shipment weight is below a certain minimum weight, generally 200 to 300 pounds for trucking. Service is often less favorable than for large shipments. Revenues among these services are distributed as follows: UPS truck—31.6 percent; LTL truck—39.6 percent; normal air—4.2 percent; special air[30]—24.6 percent; and rail and bus—negligible.[31]

COMPANY-CONTROLLED TRANSPORTATION

An available alternative to outsourcing transport of goods is to provide transportation service through company ownership of equipment or contracting for transportation services. Ideally, the user hopes to gain better operating performance, greater availability and capacity of transportation service, and a lower cost. At the same time, a certain amount of financial flexibility is sacrificed because the company must invest in a transportation capability or must commit itself to a long-term contractual arrangement. If the shipping volume is high, it may be more economical to own the transportation service than to rent it. However, some companies are forced to own or contract for transportation even at higher costs because their special requirements for service cannot be adequately met through common carrier services. Such requirements might include (1) fast delivery with very high dependability; (2) special equipment not generally available; (3) special handling of the freight; and (4) a service that is available on demand. Common carriers serve many customers and cannot always meet the specific transportation requirements of individual users.

INTERNATIONAL TRANSPORTATION

The success of the transportation industry in developing a fast, reliable, and efficient transportation system has substantially contributed to the dramatically expanding level (24 times) of international trade occurring in the last 30 years (about a threefold increase in revenue for international air and water movements from 1980 to 1996 alone).[32] Inexpensive transportation has allowed domestic companies to take advantage of the differences in labor rates worldwide, to secure raw materials that are geographically dispersed, and to place goods competitively in markets far from their domestic borders. Thus, the logistician must be knowledgeable about the special requirements for moving goods internationally.

Overview

Water carriers dominate international transportation, with more than 50 percent of the trade volume in dollars and 99 percent by weight. Air moves 21 percent of the

[30]Federal Express, UPS, DHL, and Airborne Express.
[31]Rosalyn A. Wilson, *Transportation in America*, 17th ed. (Washington, DC: ENO Transportation Foundation, 1999), p. 19.
[32]*Statistical Abstract of the U.S.: 1997*, p. 656.

dollar trade volume, and the remainder is transported by truck, rail, and pipeline between bordering countries.

The dominance of particular transport modes is largely affected by the geography of the country and the proximity of major trading partners. Island countries, such as Japan and Australia, must use air and water modes extensively. However, many of the member countries of the European Union can make use of rail, truck, and pipeline modes.

Route choices become much more restricted than in domestic movement because goods must move through a limited number of ports and customs points in order to leave or enter a country. Although this may make routing easier and more obvious as compared with domestic movements, the problems brought about by the legal requirements of moving goods between two or more countries and the more limited liability of international carriers as compared with domestic carriers can make international movement more complex. That is, international shipments must move under more documents than domestic shipments, are subject to delays brought about by the legal requirements for entering and exiting a country, and are subject to the routing restrictions of two or more countries. In addition, limited carrier liability (ocean carriers need only provide a seaworthy vessel as evidence of responsibility) results in increased protective packaging, and increased insurance and documentation costs as a hedge against potential loss. This helps to explain some of the popularity of containerization for moving high-valued goods in international markets.

Physical Plant

The physical plant for international transportation differs only in a few respects from the domestic system. The transportation equipment is of the same type except the size may differ somewhat. The physical routes are different because they cover different geographic territories than do domestic routes. However, a distinct difference is the foreign trade zone and the role that it plays in the routing of international shipments.

Customers' expenses, tariffs, duties, and taxes are assessments that governments place on imported goods. These often prove burdensome to the exporter. The exporter may find it a disadvantage to pay duties to the importing country at the time and in the form that goods are received for import, and/or the exporter might like to use the labor of the importing country or its strategic location for manufacturing and storage but finds it uneconomical because of the duties. Foreign trade zones, or free ports, eliminate this disadvantage, to the benefit of both the exporting and importing countries. There is no direct counterpart to the trade zone in domestic trade.

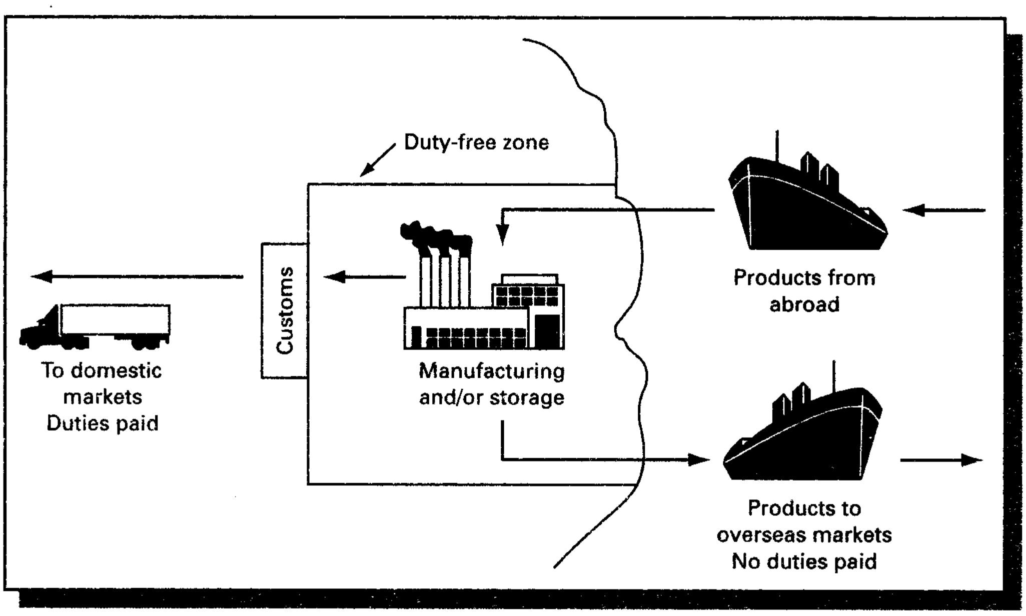
Trade zones are duty-free areas established at one or more entry points within a country, such as seaports and airports, where foreign goods may enter, be held or processed in some way, and be reshipped without incurring any duties. Figure 6-2 shows a diagram of how the trade zone operates. There are 225 general-purpose zones and 359 subzones located in the United States.[33] They can offer numerous

[33]Web site for the National Association of Foreign-Trade Zones, found at www.naftz.org.

advantages to the logistician responsible for international movement of goods. The important advantages of foreign trade zones can be summarized as follows:

1. Imported goods may be left at trade zones for storage, manipulation to change custom classification, assembly, exhibition, grading, cleaning, selling, mixing with foreign and domestic merchandise, repacking, destruction, sorting, and other services and then shipped out of the zone to another country without customs formalities or control.
2. Foreign governments pay duties on goods in the trade zone only when they enter the customer's territory of the importing country.
3. Imported goods that are improperly marked for entry into the domestic market can be remarked at the trade zones, thus avoiding fines on the goods.
4. Goods may be repacked into smaller or larger quantities.
5. Goods that undergo shrinkage to spoilage, evaporation, or damage do not incur duties on the amount lost.
6. Savings sometimes can be realized through shipping goods unassembled to the zone and then assembling them.
7. The capital tied up in duties and bonds can be released for more profitable uses when products using duty-subject foreign materials are shipped to the trade zones to remain until foreign buyers are found or buyers are ready for delivery.
8. Importers may obtain privileged foreign trade status whereby duties are frozen against future increases.

Figure 6-2 Operation of a Foreign (Free) Trade Zone



9. Manufacturing conducted in trade zones incurs duties only on the imported materials and component parts in the finished product entering into the domestic market.
10. Tangible personal property is generally exempt from state and local taxes.
11. Customs security requirements provide protection against theft.
12. Merchandise may remain in a zone indefinitely.[34]

Foreign (free) trade zones become forward bases for goods moving to or for goods received from foreign markets or suppliers. The advantages that they provide may well affect the routing of goods. Bonded warehouses, both public and private, can serve as foreign trade zones.

Application

Dorcy International Inc. is an assembler of flashlights and lanterns, the supplies for which are imported from China. Historically, Dorcy paid a 12.5 percent duty on parts as soon as they arrived on the West Coast. Now, yellow and black flashlights are freighted from China and shipped by rail to the abandoned Rickenbacker military base near Columbus, Ohio, which has become a foreign trade zone. By establishing the operation within the Rickenbacker trade zone, Dorcy has postponed duties until the goods are assembled, packed, and shipped to customers such as Sears, Wal-Mart, and Kmart—a process that can take 30 days. The delayed payment of duties can save Dorcy hundreds of thousands of dollars per year. And if the flashlights are assembled and exported to another country, no duties are paid at all. For tax purposes, it is as if the product never landed in the United States.[35]

Agencies and Services

Another distinguishing characteristic of international transportation is the number and variety of middlemen, or agents, that can assist the shipper or buyer engaged in international transportation. These include customhouse brokers, international freight forwarders, export merchants, export agents, export commission houses, import commission houses, wholesalers (or jobbers), brokers, international departments of banks, and the like. When agents are used, they provide more services than just transportation. They handle getting shipments across borders. This can include preparing paperwork for customs, coordinating customs inspections, shipment warehousing and consolidation, freight optimization, and shipment tracking.

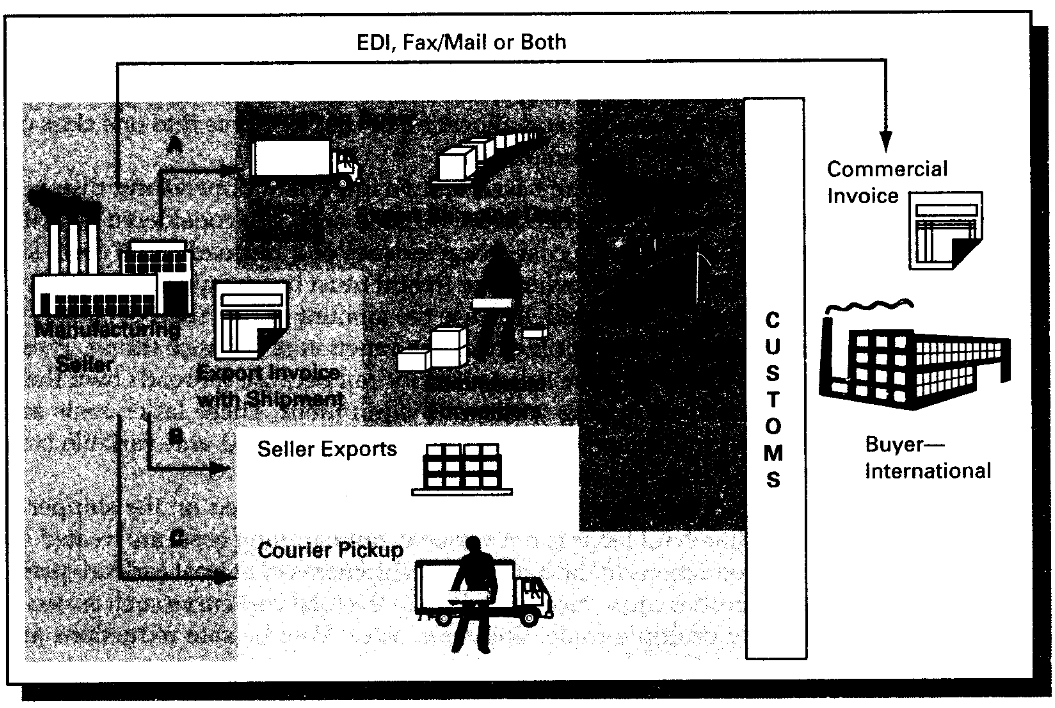
[34]Derived from an excellent discussion of trade zones by Gordon E. Miracle and Gerald S. Albaum, *International Marketing Management* (Homewood, IL: Richard D. Irwin, 1970), pp. 438–445; Pat J. Calabro, "Foreign Trade Zones—A Sleeping Giant in Distribution," *Journal of Business Logistics*, Vol. 4, No. 1 (1983), 51–64; Web site for the National Association of Foreign-Trade Zones, www.naftz.org; and Dick Morreale, "Logistics Rules of Thumb IV," www.logfac.com (August 2001).
[35]Clarke Ansberry, "For This Midwest City, Slow and Steady Wins Today's Economic Race," *The Wall Street Journal*, February 22, 2001, A1ff.

However, firms with significant international activity may establish special groups within their own traffic department to handle international transportation matters.

Example

The Parker-Hannifin Corporation is a world leader in the manufacture of hydraulic equipment such as hose, fittings, cylinders, seals, controls, and filters. Manufacturing takes place in the United States, Europe, and Asia with sales in nearly every country. International sales are handled in three ways. As shown in Figure 6-3, shipments may be handled through an agent (A). Product is trucked to a warehousing location where small shipments are consolidated into large ones. A freight forwarder, either an air or ocean carrier, is used to transport the goods to the final destination. The second alternative (B) is to ship directly with an air or ocean carrier where there is significant volume going to a particular region. This is a reasonable choice when shipments are larger than those in A. Finally, a courier service can be used (C) such as FedEx or UPS. This alternative is particularly attractive for rush orders. Air is the dominant mode used in this case. Using a variety of shipping methods allows Parker to carefully match shipping efficiency considerations with customer service needs.

Figure 6-3 Alternative Shipping Methods for International Customers of the Parker-Hannifin Corporation



Transport Cost Characteristics

The prices a logistician must pay for transportation services are keyed to the cost characteristics of each type of service. Just and reasonable transportation rates tend to follow the costs of producing the service. Because each service has different cost characteristics, under any given set of circumstances there will be potential rate advantages of one mode that cannot be effectively matched by other services.

Variable and Fixed Costs

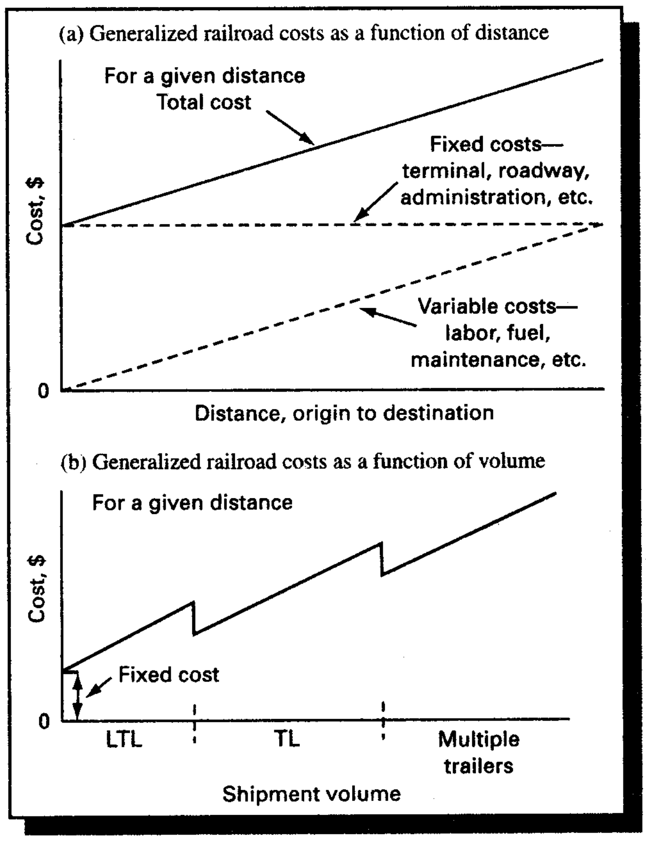
A transportation service incurs a number of costs, such as labor, fuel, maintenance, terminal, roadway, administrative, and others. This cost mix can be arbitrarily divided into those costs that vary with services or volume (variable costs) and those that do not (fixed costs). Of course, all costs are variable if a long enough time and a great enough volume are considered. For purposes of transport pricing, however, it is useful to consider costs that are constant over the "normal" operating volume of the carrier as fixed. All other costs are treated as variable.

Specifically, fixed costs are those for roadway acquisition and maintenance, terminal facilities, transport equipment, and carrier administration. Variable costs usually include line-haul costs such as fuel and labor, equipment maintenance, handling, and pickup and delivery. This is not a precise allocation between fixed and variable costs, as there are significant cost differences between transportation modes, and there are different allocations depending on the dimension being examined. All costs are partly fixed and partly variable, and allocation of cost elements into one class or the other is a matter of individual perspective.

Line-haul transportation rates are based on two important dimensions: distance and shipper volume. In each case, fixed and variable costs are considered slightly different. To illustrate, consider the cost characteristics of a railroad. Total costs for service vary with the distance over which the freight must be transported, as shown in Figure 6-4(a). This is to be expected, because the amount of fuel used depends on distance, and the amount of labor for the haul is a function of distance (time). These are the variable costs. Fixed costs are substantial for rail because railroads own their roadways, terminals and switching yards, and equipment. These latter costs are treated as invariant with distance traveled. The sum of the fixed and variable cost elements gives the total cost.

In contrast, Figure 6-4(b) shows a railroad cost function based on the shipper's volume. In this case, line-haul labor is not variable, but handling costs are treated as variable. Significant reductions in the handling of shipments of at least carload quantities or trainload quantities cause discontinuities in the total cost curve such as occur between LTL, TL, and multiple-trailer shipment sizes. Volume rate reductions are usually pegged to these drops in costs.

Figure 6-4
Generalized Railroad Costs (and Revenues) As Functions of Volume and Distance



Common or Joint Costs

It was mentioned previously that reasonable transport rates are those that follow the costs of producing the service. Beyond the problem of deciding whether a cost is fixed or variable, determining what the actual costs are for a particular shipment requires some arbitrary cost allocations, even though the total costs of operating may not be known. The reason is that many transportation costs are indivisible. Many shipments in different sizes and weights move jointly in the same haul. How much of the cost should be assigned to each shipment? Should the costs be assigned based on shipment weight to total load, on the proportion of total cubic footage used, or on some other basis? There is no simple formula for cost allocation, and production costs on a per-shipment basis remain a matter of judgment.

The back haul that all carriers experience, with the exception of pipeline, is a case in point. Carriers rarely can perfectly balance the traffic between the forward movement and the return (back haul) movement. By definition, the forward haul is the heavy traffic direction and the back haul is the light traffic direction. Shipments in the back haul may be allocated their fair share of total costs of producing the back haul. This makes the cost per shipment high compared with the forward haul. The back haul may be treated as a byproduct of the forward haul because it results from producing the forward haul. All, or most of the costs, are then allocated to forward-haul shipments. Back-haul costs would be considered zero, or assigned only the direct costs to move a shipment in the back-haul direction.

There are several dangers in the latter approach. For one, rates on the forward haul may have to be set at a level that would restrict volume in this direction. In addition, back-haul rates could be set low to help cover some fixed expenses. The effect may be that the back haul gains significantly in volume and possibly surpasses the forward-haul volume. A carrier then may find itself not meeting its fixed expenses and facing rate adjustments that could greatly alter the traffic balance. The by-product has now become the main product. In addition, a significant difference in cost allocation and in rates that follow these costs may lead to questions of rate discrimination between forward-haul and back-haul shippers. The key to discrimination is whether the service in both directions is judged to be under essentially the same conditions and circumstances.

Cost Characteristics by Mode

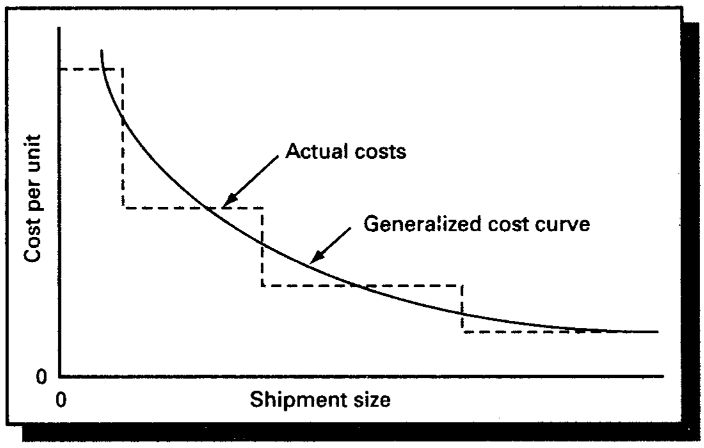
The type of services that a carrier is likely to emphasize is indicated by the nature of the general cost function under which it operates and by the relationship of the function to those of other carriers.

Rail

As a transporter of freight and passengers, the railroad has high fixed costs and relatively low variable costs. Loading, unloading, billing and collecting, and yard switching of multiple-product, multiple-shipment trains contribute to high terminal costs for rail. Increased per-shipment volume and its effect on reducing terminal costs result in some substantial economies of scale, that is, lower per-unit costs for increased per-shipment volume. Roadway maintenance and depreciation, terminal facility depreciation, and administration expenses also add to the level of fixed cost. Railroad line-haul costs, or variable costs, typically include wages, fuel, oil, and maintenance. Variable costs by definition vary proportionately with distance and volume; however, a degree of indivisibility does exist in some variable costs (labor, for example), so variable costs per unit will decrease slightly. Traditionally, variable costs have been taken as one-half to one-third of total costs, although there is a great deal of controversy over the exact proportion.

The net effect of high fixed costs and relatively low variable costs is to create significant economies of scale in railroad costs. Distributing the fixed costs over greater volume generally reduces the per-unit costs, as shown in Figure 6-5. Similarly, rail ton-mile costs drop when fixed costs are allocated over increasing lengths of haul.

Figure 6-5
Generalized Surface Carrier Cost Structure Based on Shipment Size



Highway

Motor carriers show contrasting cost characteristics with rail. Their fixed costs are the lowest of any carrier because motor carriers do not own the roadway over which they operate, the tractor-trailer represents a small economic unit, and terminal operations do not require expensive equipment. On the other hand, variable costs tend to be high because highway construction and maintenance costs are charged to the users in the form of fuel taxes, tolls, and weight-mile taxes.

Trucking costs are mainly broken down into terminal expenses and line-haul expenses. Terminal expenses, which include pickup and delivery, platform handling, and billing and collecting, are 15 to 25 percent of total trucking expenses. These expenses, on a dollar-per-ton basis, are highly sensitive to shipment sizes below 2,000 to 3,000 pounds. Terminal expenses for shipments larger than 3,000 pounds continue to drop as pickup and delivery and handling costs are spread over larger shipment sizes. However, the reduction is far less dramatic than for small shipment sizes. The costs as a function of shipment size follow the same general form as previously shown in Figure 6-5.

Line-haul trucking costs are 50 to 60 percent of total costs. It is not clear that per-unit, line-haul costs necessarily decrease with distance or volume. However, total-unit trucking costs do decrease with shipment size and distance as terminal costs and other fixed expenses are spread over more ton-miles, but not as dramatically as rail costs.

Water

The major capital investment that a water carrier makes is in transport equipment and, to some extent, terminal facilities. Waterways and harbors are publicly owned and operated. Little of this cost, especially for inland waterway operations, is charged back to water carriers. The predominant fixed costs in a water carrier's budget are associated with terminal operations. Terminal costs include the harbor fees, as the carrier enters a seaport, and the costs for loading and unloading cargo. Loading and unloading times are particularly slow for water carriers. High stevedoring costs make terminal costs almost prohibitive for all but bulk commodities and containerized freight where mechanized materials-handling equipment can be used effectively.

These typically high terminal costs are somewhat offset by very low line-haul costs. Without user charges for the waterways, variable costs include only those costs associated with operating the transport equipment. Operating costs (excluding labor) are particularly low because of the minimal drag to movement at slow speeds. With high terminal costs and low line-haul costs, ton-mile costs drop significantly with distance and shipment size. Thus, water is one of the least expensive carriers of bulk commodities over long distances and in substantial volume.

Air

Air transportation has many of the same cost characteristics as water and highway carriers. Airline companies generally do not own the air space nor the air terminals. Airlines purchase airport services as needed in the form of fuel, storage, space rental, and landing fees. If we include ground handling and pickup and delivery in the case of airfreight operations, these costs are the terminal costs for air transportation. In addition, airlines own (or lease) their own equipment, which, when depreciated over its economic life, becomes an annual fixed expense. In the short run, airline variable expenses are influenced more by distance than by shipment size. Because an aircraft has its greatest inefficiency in the takeoff and landing phases of operation, variable costs are reduced by the length of haul. Volume has indirectly influenced variable costs as greater demand for air transportation services has brought about larger aircraft that have lower operating costs per available ton-mile.

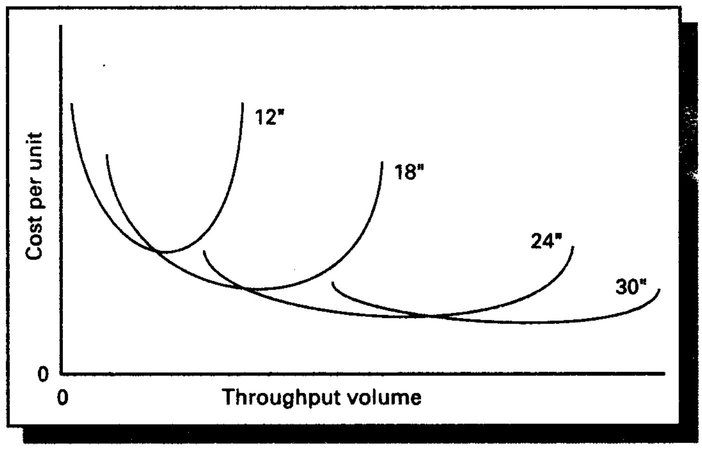
Combined fixed and variable expenses generally make air transportation a premium service, especially for short distances; however, distribution of terminal expenses and other fixed charges over increased volume offers some reduction in per-unit costs. Substantial per-unit cost reductions come from operating aircraft over long distances.

Pipeline

Pipeline parallels the railroad in its cost characteristics. Pipeline companies, or the oil companies that own the pipelines, own the pipe, terminals, and pumping equipment. They may own or lease the right-of-way for the pipe. These fixed costs, with the addition of other costs, give pipeline the highest ratio of fixed cost to total cost of any mode. To be competitive, pipelines must work on high volume over which to spread these high fixed costs.

Variable costs mainly include power to move the product (usually crude oil or refined petroleum products) and costs associated with the operation of pumping stations. Power requirements vary markedly, depending on the line throughput and the diameter of the pipe. Larger pipes have disproportionately less circumference to cross-sectional area as compared with smaller pipes. Frictional losses, and therefore pumping power, increase with the pipe circumference, and volume increases with the cross-sectional area. As a result, costs per ton-mile decrease substantially with larger pipes, if there is sufficient throughput to justify the larger pipe. There are also diminishing returns to scale if too large a volume is forced through pipe of a given size. These general cost characteristics are shown in Figure 6-6.

Figure 6-6
Generalized Pipeline Costs As Functions of Pipe Diameter and Throughput Volume



RATE PROFILES

Transportation rates are the prices that for-hire carriers charge for their services. Various criteria are used in developing rates under a variety of pricing situations. The most common rate structures are related to volume, distance, and demand.

Volume-Related Rates

The economies of the transportation industry show that costs of service are related to the shipment size. Rate structures in general reflect these economies, as shipments in consistently high volumes are transported at lower rates than smaller shipments. Volume is reflected in the rate structure in several ways. First, rates may be quoted directly on the quantity shipped. If the shipment is small and results in very low revenue for the carrier, the shipment will be assessed either a minimum charge or an any-quantity (AQ) rate. Larger shipments that result in charges greater than the minimum charge but are less than a full-vehicle-load quantity are charged at a less-than-vehicle load rate that varies with the particular volume. Large shipment sizes that equal or exceed the designated vehicle-load quantity are charged the vehicle-load rate.

Second, the system of freight classification permits some allowance for volume. High volume can be considered justification for quoting a shipper special rates on particular commodities. These special rates are considered deviations from the regular rates that apply to products shipped in lesser volume.

Volume-related rate structures are more complex than this discussion indicates. However, because much of the following section on transport rates is concerned with volume, further discussion is deferred until later in this chapter.

Distance-Related Rates

Rates, as a function of distance, range from being completely invariant with distance to varying directly with distance, with most rate structures lying between these extremes.

Uniform Rates

Simplicity can be a key factor in establishing a rate structure. The simplest of all is the uniform rate structure in which there is one transport rate for all origin-to-destination distances [Figure 6-7(a)]. An example is the first-class postage rates in the United States. The uniform rate structure for mail is justified because a large portion of the total cost for delivering mail is in handling. Handling costs are shipment, not distance, related. On the other hand, using a uniform rate structure for truck transportation, where line-haul costs are at least 50 percent of total cost, would raise serious questions of rate discrimination.[36]

Proportional Rates

For those carriers with significant line-haul cost components (truck and, to a lesser extent, air), a compromise between rate structure simplicity and service costs is provided by the proportional rate structure [Figure 6-7(b)]. By knowing only two rates, one can determine all other rates for a commodity by straight-line extrapolation. Although there are some obvious advantages to this simple structure, it does adversely discriminate against the long-haul shipper in favor of the short-haul shipper. Terminal charges are not recovered on the short haul. Truckload rates can have this characteristic because handling costs are minimal.

Tapering Rates

A common rate structure is built upon the tapering principle. Because in the United States terminal charges are typically included in line-haul charges, a rate structure that follows costs will show rates increasing with distance but at a decreasing rate, as shown in Figure 6-7(c). A major reason for this shape is that with increased distance of the shipment, terminal costs and other fixed charges are distributed over more miles. The degree of taper will depend on the level of fixed costs that a carrier has and the extent of economies of scale in line-haul operations. Thus, if only economies dictate the rate structure, we logically would expect greater taper for rail, water, and pipe than for truck and air.

Blanket Rates

The desire to meet the competitors' rates and to simplify rate publications and administration led carriers to establish blanket rate structures. Blanket rates are merely single rates that cover a wide area at the origin, destination, or both. The

[36]Discrimination is assumed to occur whenever rates do not follow the costs of producing the service in question.