Transport Decisions in Logistics/Supply Chain Management

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“Sometimes your only available transportation is a leap of faith.”

Margaret Shepherd
Author, Artist
Transport Decisions in Transport Strategy

- Inventory Strategy
  - Forecasting
  - Inventory decisions
  - Purchasing and supply scheduling decisions
  - Storage fundamentals
  - Storage decisions

- Transport Strategy
  - Transport fundamentals
  - Transport decisions

- Customer service goals
  - The product
  - Logistics service
  - Ord. proc. & info. sys.

- Location Strategy
  - Location decisions
  - The network planning process
Typical Transport Decisions

• Mode/Service selection
• Private fleet planning
  – Carrier routing
  – Routing from multiple points
  – Routing from coincident origin-destination points
  – Vehicle routing and scheduling
• Freight consolidation

Just a few of the many problems in Transportation
Transport Service Selection

• Selection of a mode of transportation or service offering within a mode of transportation depends on a variety of service characteristics.

• Six variables are key to transport service choice:
  (1) freight rates, (2) reliability, (3) transit time, (4) loss, damage, claims processing, and tracing, (5) shipper market considerations, and (6) carrier considerations. [McGinnis]
Basic Cost Trade-Offs

- When transportation service is not used to provide a competitive advantage, the best service choice is found by trading off the cost of using a particular transport service with the indirect cost of inventory associated with the performance of the selected node.
- That is, speed and dependability affect both the shipper's and the buyer's inventory levels (both order quantity stock and safety stock) as well as the amount of inventory that is in transit between the shipper's and buyer's locations.
- As slower, less reliable services are selected, more inventory will appear in the channel.
- Inventory-carrying cost may be in trade-off with lower cost for the transportation service.
- Given alternatives, the favored service will be the one that offers the lowest total cost consistent with customer service goals while meeting customer service objectives.
• **The problem**
  – Define the available choices
  – Balance performance effects on inventory against the cost of transport

• **Methods for selection**
  – Indirectly through network configuration
  – Directly through channel simulation
  – Directly through a spreadsheet approach

**Cost type**
– Transportation
– In-transit inventory
– Source inventory
– Destination inventory
Example 1: Finished goods are to be shipped from a plant inventory to a warehouse inventory some distance away. The expected volume to be shipped in a year is 1,200,000 lb. The product is worth $25 per lb. and the plant and carrying costs are 30% per year.

Other data are:

<table>
<thead>
<tr>
<th>Transport choice</th>
<th>Rate, $/lb.</th>
<th>Transit time, days</th>
<th>Shipment size, lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>0.11</td>
<td>25</td>
<td>100,000</td>
</tr>
<tr>
<td>Truck</td>
<td>0.20</td>
<td>13</td>
<td>40,000</td>
</tr>
<tr>
<td>Air</td>
<td>0.88</td>
<td>1</td>
<td>16,000</td>
</tr>
</tbody>
</table>
# Transport Selection Analysis

<table>
<thead>
<tr>
<th>Cost Type</th>
<th>Computation</th>
<th>Rail</th>
<th>Truck</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>RD</td>
<td>0.11(1,200,000)</td>
<td>0.20(1,200,000)</td>
<td>0.88(1,200,000)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= $132,000</td>
<td>= $240,000</td>
<td>= $1,056,000</td>
</tr>
<tr>
<td>In-transit inventory</td>
<td>ICDT</td>
<td>0.30(25) 1,200,000(25)/365</td>
<td>0.30(25) 1,200,000(13)/365</td>
<td>0.30(25) 1,200,000(1)/365</td>
</tr>
<tr>
<td></td>
<td>365</td>
<td>= $616,438</td>
<td>= $320,548</td>
<td>= $24,658</td>
</tr>
<tr>
<td>Plant inventory</td>
<td>ICQ</td>
<td>0.30(25) 100,000/2</td>
<td>[0.30(25) 40,000/2</td>
<td>[0.30(25) 16,000/2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>= $375,000</td>
<td>= $150,000</td>
<td>= $60,000</td>
</tr>
<tr>
<td>W/H inventory</td>
<td>ICQ</td>
<td>0.30(25.11) 100,000/2</td>
<td>[0.30(25.20) 40,000/2</td>
<td>[0.30(25.88) 16,000/2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>= $376,650</td>
<td>= $151,200</td>
<td>= $62,112</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>$1,500,088</td>
<td>$861,748</td>
<td>$1,706,770</td>
</tr>
</tbody>
</table>

*Include transport rate*
**Example 2:** An appliance manufacturer located in Pittsburgh purchases 3,000 cases of plastic parts valued at $100 per case from two suppliers. Purchases are currently divided equally between the suppliers. Each supplier uses rail transport and achieves the same average delivery time. However, for each day that a supplier can reduce the average delivery time, the appliance manufacturer will shift 5% of its total purchases, or 150 cases, to the supplier offering the premium delivery service. A supplier earns a margin of 20 percent on each case before transportation charges. Supplier A would like to consider whether it would be beneficial to switch from Rail to air or truck modes. The following transportation rates per case and average delivery times are known for each mode:

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Transport rate</th>
<th>Delivery Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>$2.50/case</td>
<td>7 days</td>
</tr>
<tr>
<td>Truck</td>
<td>6.00</td>
<td>4</td>
</tr>
<tr>
<td>Air</td>
<td>10.35</td>
<td>2</td>
</tr>
</tbody>
</table>
Supplier A's choice can simply be made based on the potential profits to be received. Table below shows the profits from supplier A's perspective for a transport modal choice.

If the appliance manufacturer remains true to its promise to increase its patronage to the supplier with the better delivery service, supplier A should switch to truck delivery.

Of course, supplier A should be watchful of any countermoves by supplier B that may neutralize this advantage.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cases Sold</th>
<th>Gross Profit</th>
<th>Transport Cost</th>
<th>Net Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>1,500</td>
<td>30,000.00</td>
<td>-</td>
<td>26,250.00</td>
</tr>
<tr>
<td>Truck</td>
<td>1,950</td>
<td>39,000.00</td>
<td>11,700.00</td>
<td>27,300.00</td>
</tr>
<tr>
<td>Air</td>
<td>2,250</td>
<td>45,000.00</td>
<td>23,287.50</td>
<td>21,712.50</td>
</tr>
</tbody>
</table>
• The methods discussed for the transport service selection problem recognize the need to account for the indirect effect that transportation choice has on inventory costs and the patronage of the logistics channel member receiving the transportation mode performance offering. This is in addition to the direct cost of the service provided.

• However, there are often other factors to be considered, some of which are not under the control of the decision maker.
Appraisal of Selection Methods

• First, effective cooperation between supplier and buyer is encouraged if a reasonable knowledge of each party's cost is available. If the supplier and the buyer are separate legal entities, it is doubtful that perfect cost information is possible unless some form of information exchange is worked out. In any case, sensitivity to the other party's reactions to a transport service choice or to the degree of patronage should indicate the direction of cooperation.

• Second, where there is a competing supplier in the distribution channel, the buyer and the supplier should act rationally to gain optimum cost-transport service trade-offs. Of course, rationality among the parties cannot be guaranteed.

• Third, price effects have not been considered. If a supplier were to provide a higher quality transportation service than the competition, he might raise the product price to compensate, at least in part, for the added cost. The buyer should consider both price and transport performance when determining patronage.
Fourth, transport rate changes, changes in product mix, and inventory cost changes, as well as possible transport service retaliation by a competing supplier, add a dynamic element to the problem that is not directly considered.

Fifth, the indirect effects of transport choice on supplier inventories are not evaluated. Suppliers may experience increased or decreased inventory levels resulting from the shipment size associated with the transport choice, just as does the buyer. Suppliers may adjust price to reflect this, which, in turn, will affect transport choice.
• Because transportation costs typically range between one-third and two-thirds of total logistics costs, improving efficiency through the maximum utilization of transportation equipment and personnel is a major concern.

• The length of time that goods are in transit reflects on the number of shipments that can be made with a vehicle within a given period and on the total transportation costs for all shipments.

• To reduce transportation costs and to improve customer service, finding the best paths that a vehicle should follow through a network of roads, rail lines, shipping lanes, or air navigational routes that will minimize time or distance is a frequent decision problem.
Vehicle Routing problems

• Problem of finding a path through a network
  – where the origin point is different from the destination point.
  – where origin and destination points are the same
  – where multiple origin and destination points.
Vehicle Routing problems – Solution Methods

- **Shortest route method** - for Separate and Single Origin and Destination Points

![Diagram showing vehicle routing problem](image)

*Note: All link times are in minutes*

*Can be a weighted index of time and distance*
Vehicle Routing problems – Solution Methods

• **Transportation method** - for Multiple Origin and Destination Points

• This problem is solved by the traditional transportation method of **linear programming**
Vehicle Routing problems – Solution Methods

Example: Routing from Multiple Points

<table>
<thead>
<tr>
<th>From \ To</th>
<th>Plt 1</th>
<th>Plt 2</th>
<th>Plt 3</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sup A</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>400</td>
</tr>
<tr>
<td>Sup B</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>700</td>
</tr>
<tr>
<td>Sup C</td>
<td>9</td>
<td>5</td>
<td>8</td>
<td>500</td>
</tr>
<tr>
<td>Demand</td>
<td>600</td>
<td>500</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

**Results**

<table>
<thead>
<tr>
<th>From \ To</th>
<th>Plt 1</th>
<th>Plt 2</th>
<th>Plt 3</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sup A</td>
<td>400</td>
<td>0</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>Sup B</td>
<td>200</td>
<td>200</td>
<td>300</td>
<td>700</td>
</tr>
<tr>
<td>Sup C</td>
<td>0</td>
<td>300</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>Demand</td>
<td>600</td>
<td>500</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

*The transportation rate in $ per ton for an optimal routing between supplier A and plant 1*
Vehicle Routing problems – Solution Methods

Method for Coincident Origin and Destination Points

• Extension of the problem of separate origin and destination points, but the tour is not complete until the vehicle returns to its starting point which adds a complicating dimension.
• commonly occurs when transport vehicles are privately owned.
• Examples
  – Beverage delivery to bars and restaurants
  – Currency delivery and scheduling at ATM machines
  – Dynamic sourcing and transport of fuels
  – Home appliance repair, service, and delivery
  – Postal delivery truck routing
  – School bus routing
  – Newspaper delivery, etc.
Vehicle Routing problems – Solution Methods

• Methods for Coincident Origin and Destination Points
  – Traveling salesman problem (TSP)
  – Vehicle routing and scheduling problem (VRP)
Freight Consolidation

• Combine small shipments into larger ones
• A problem of balancing cost savings against customer service reductions
• An important area for cost reduction in many firms
• Based on the rate-shipment size relationship for for-hire carriers
4 Ways of Freight Consolidation

• First, there is inventory consolidation. That is, an inventory of items is created from which demand is served. This allows large and even full vehicle-load shipments to be made into the inventory.

• Second, there is vehicle consolidation. In this case, where pickups and deliveries involve less than vehicle-load quantities, more than one pickup or delivery is placed on the same vehicle for more efficient transport. Vehicle routing and scheduling procedures exploit this type of economy.
4 Ways of Freight Consolidation

- Third, there is **warehouse consolidation**. The fundamental reason for warehousing is to allow the transportation of large shipment sizes over long distances and the transportation of small shipment sizes over short distances. A warehouse used in a break-bulk operation is an example.

- Fourth, there is **temporal consolidation**. In this case, orders from customers are held so that a few larger shipments may be made at one time, rather than making many small shipments at various times. Economies in transportation are achieved through improved routing of the larger shipments as well as through lower per-unit rates. Of course, these costs are typically in trade-off with the effects of service deterioration that result from not shipping orders as soon as they are received and filled. The cost savings are obvious, but the effect on service may be difficult to estimate.
Freight Consolidation Analysis

- **Example**: Suppose we have the following orders for the next three days.

<table>
<thead>
<tr>
<th>From</th>
<th>Ft Worth</th>
<th>To: Topeka</th>
<th>Day 1</th>
<th>To: Kansas City</th>
<th>Day 2</th>
<th>To: Wichita</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5,000 lb.</td>
<td>7,000</td>
<td>25,000</td>
<td>12,000</td>
<td>18,000</td>
<td>61,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>42,000</td>
<td></td>
<td>21,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Consider shipping these orders each day or consolidating them into one shipment. Suppose that we know the transport rates.
**Freight Consolidation Analysis**

1) **Separate shipments**

<table>
<thead>
<tr>
<th>Location</th>
<th>Rate x Volume</th>
<th>Day 1</th>
<th>Rate x Volume</th>
<th>Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topeka</td>
<td>3.42 x 50</td>
<td>= $171.00</td>
<td>1.14 x 250</td>
<td>= $285.00</td>
</tr>
<tr>
<td>Kansas City</td>
<td>3.60 x 70</td>
<td>= 252.00</td>
<td>1.44 x 120</td>
<td>= 172.80</td>
</tr>
<tr>
<td>Wichita</td>
<td>0.68 x 420</td>
<td>= 285.60</td>
<td>0.68 x 400(^a)</td>
<td>= 272.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$708.60</strong></td>
<td></td>
<td><strong>$729.80</strong></td>
</tr>
</tbody>
</table>

\(^a\) Ship 380 cwt., as if full truckload of 400 cwt.

2) **Day 3**

<table>
<thead>
<tr>
<th>Location</th>
<th>Rate x Volume</th>
<th>Day 3</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topeka</td>
<td>1.36 x 180</td>
<td>= $244.80</td>
<td>$700.80</td>
</tr>
<tr>
<td>Kansas City</td>
<td>1.20 x 210</td>
<td>= 252.00</td>
<td>676.80</td>
</tr>
<tr>
<td>Wichita</td>
<td>0.68 x 610</td>
<td>= 414.80</td>
<td>972.40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$911.60</strong></td>
<td><strong>$2,350.00</strong></td>
</tr>
</tbody>
</table>
Freight Consolidation Analysis

2) Consolidated shipment

Computing transport cost for one combined, three-day shipment

\[
\text{Day 3} \\
\text{Rate x volume = cost}
\]

Topeka \(0.82 \times 480^a = 393.60\)

Kansas City \(0.86 \times 400 = 344.00\)

Wichita \(0.68 \times 1410 = 958.80\)

Total \(480 = 50 + 250 + 180\)

\[\text{Total} = 1,696.40\]

\[^a 480 = 50 + 250 + 180\]

Cheaper, but what about the service effects of holding early orders for a longer time to accumulate larger shipment sizes?