The Cost of Delivering Small Orders

(from Chapter 8 of Operational Distribution Research
by Mercer, Cantley, and Rand)

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August 31, 1999
Problem Description

• 300 Products
• Each depot serves an area of about 80 kilometers radius. The problem will focus on one of those depots (Figure 1)
• 20 Vehicles
  – 17 vehicles deliver to specific areas within the depot area
  – 3 vehicles deliver large loads anywhere within the depot area
Figure 1-Distribution of Grocery Supplies from the Storage Depots
Problem Description (Continued)

• Starting and Ending Points
  – Drivers Own The trucks
  – Drivers live far away from the central depot.
  – Starting and ending points could be different than the depot

• Delivery processing is done only for orders that include five or more boxes
Problem Description (Continued)

• Deliveries are not constrained by the amount of boxes. That is, deliveries of less than 5 boxes can occur

• One goal is to establish how to better balance production and inventory costs with distribution costs.

• Another goal is to make sure that all deliveries are profitable
## Order Size Distributions for Deliveries and Sales

<table>
<thead>
<tr>
<th>Order Size (Boxes)</th>
<th>Percentage of Deliveries (Orders)</th>
<th>Percentage of Sales (Boxes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 or less</td>
<td>7.5</td>
<td>0.5</td>
</tr>
<tr>
<td>9 or less</td>
<td>26.0</td>
<td>3.5</td>
</tr>
<tr>
<td>14 or less</td>
<td>38.5</td>
<td>8.5</td>
</tr>
<tr>
<td>19 or less</td>
<td>49.0</td>
<td>11.0</td>
</tr>
<tr>
<td>24 or less</td>
<td>55.0</td>
<td>14.0</td>
</tr>
<tr>
<td>49 or less</td>
<td>77.0</td>
<td>32.5</td>
</tr>
<tr>
<td>99 or less</td>
<td>89.0</td>
<td>52.0</td>
</tr>
<tr>
<td>249 or less</td>
<td>97.0</td>
<td>82.0</td>
</tr>
</tbody>
</table>
Order Size Distributions for Deliveries and Sales (Continued)

- Two important points to note from the table above
  - 25% of the orders were for less than 10 boxes but these represented less than 5% of sales
  - 50% of the orders are below 20 boxes and accounted for only 10% of sales
Order Size Distributions for Deliveries and Sales (Continued)

- These two points underline the importance of optimizing the distribution of small orders:
  - If small retailers were remotely located, increasing the minimum order threshold would almost halve the distribution costs and increase profitability
  - If small retailers are located near larger retailers, increasing the minimum order threshold would have an insignificant effect on distribution costs and profitability
The Simulation

• All orders for a period of time were extracted from the system and the depot manager was presented with batches on a day-to-day basis

• Three simulation scenarios were run:
  – Current conditions
  – Orders for only 10 boxes or more are processed
  – Orders for only 20 boxes or more are processed
The Simulation (Continued)

- The objective in running the scenarios is to find the least expensive way of operating the distribution network
- Current conditions are summarized in Figure 2
- Other simulation results are summarized in Figures 3, and 4.
Figure 2 - Current Distribution of Calls per Week at Each Retailer

Number of calls:
- 1 - 4
- 5 - 8
- 9 - 12
+ 13 - 16
x 17 - 20
o 21 or more
Figure 3-Simulation with Minimum Order Size of 10 Boxes

<table>
<thead>
<tr>
<th>Number of calls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 4</td>
</tr>
<tr>
<td>5 - 8</td>
</tr>
<tr>
<td>9 - 12</td>
</tr>
<tr>
<td>13 - 16</td>
</tr>
<tr>
<td>17 - 20</td>
</tr>
<tr>
<td>21 or more</td>
</tr>
</tbody>
</table>
Figure 4-Simulation with Minimum Order Size of 20 Boxes

Number of calls
- 1 – 4
- 6 – 8
- 9 – 12
+ 13 – 16
× 17–20
○ 21 or more
Results

• By increasing the minimum order size, vehicles deliver a smaller amount of larger orders
• Vehicle capacity becomes a critical constraint in the optimization analysis
• Overall, no significant benefits arise from raising the minimum customer order levels:
  – On average, retailers are located very close to each other
  – Small orders are placed from locations that are in close proximity to the locations from which large orders are placed
  – Cost savings arise from the use of fewer vehicles
Result Improvements

Results could be improved by:

• Limiting the lower ordering threshold
• Conditioning which orders below the threshold can be processed
  – Process all those orders that are placed by traditionally large customers
  – Process all those orders that are either within a certain distance radius or within delivery time range from any single major-order location
  – Process all those orders that are either within a certain distance radius or within delivery time range from a given number of major-order locations