PILOT Freight Services Facility Location Optimization for Last-mile Delivery

MIT Research Fest
Cambridge, May 21st 2019
Agenda

- Background Information
- Project Introduction
  - Methodology
  - Results & Discussion
  - Recommendation
- Q&A
Pilot Freight Services

24/7 full-mile **Freight Forwarding** Services

Privately held; HDQ in Lima, PA

Operations in **more than 75 locations** throughout US & western Europe

Specialized for **heavy, bulky goods**
- Furniture
- Home Appliances & Electronics
- Sporting Equipment

Strategic acquisition for **e-commerce service offering**
Introduction

The company seeks to remain competitive by optimizing their network footprint and operating cost for last-mile delivery of heavy-bulk goods.

Anticipate e-commerce retailers will arrange mid-mile delivery to Pilot Cross-docks.

Project aims to determine the optimal number of local stations’ locations in order to minimize the last-mile logistics cost.

In Scope

San Francisco
Los Angeles
Chicago
New York
Newark
Atlanta
Dallas
Project Hypotheses

The objective is to test the hypothesis that establishing additional cross-docking facilities within metropolitan areas would reduce the mileage, and thereby the cost, of travelling from the cross-dock to final delivery.

Hypotheses

1. Pilot’s cost position will improve from optimized station locations which reduce stem time for last-mile delivery

2. Additional stations should enhance the capability to meet the growth and variation of e-commerce demand

Qualitative Considerations

- **Feasibility** of operating in urban areas
- **Limitations** including demand uncertainty, seasonality and cost fluctuations
Arriving at a recommendation requires collecting data and understanding the baseline, designing two models, and finally analyzing the results.
Results: Center of Gravity (COG) Analysis

The COG approach aims to select the location of a facility to minimize the weighted-average distance to all the demand points.

### Facility Constraint

- The greatest reduction in miles occurs when the first incremental facility is added in a market. Additional facilities were at **diminishing returns**.
- **COG provided valuable information** to seed the next major stage of our research - the MILP model.
- In Atlanta, Dallas and Chicago, a **two-station solution** is proposed. For California, New York & New Jersey, a **four-station** is proposed.

<table>
<thead>
<tr>
<th>City</th>
<th>Baseline</th>
<th>Two Sites (COG)</th>
<th>Reduction (mi)</th>
<th>Baseline</th>
<th>Two Sites (COG)</th>
<th>Reduction (points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>51</td>
<td>35</td>
<td>-16</td>
<td>33.6%</td>
<td>21.4%</td>
<td>-12.2%</td>
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<tr>
<td>Dallas</td>
<td>31</td>
<td>21</td>
<td>-10</td>
<td>14.6%</td>
<td>6.6%</td>
<td>-8.0%</td>
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<tr>
<td>Chicago</td>
<td>22</td>
<td>18</td>
<td>-4</td>
<td>8.0%</td>
<td>7.3%</td>
<td>-0.7%</td>
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<tr>
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<td>29</td>
<td>-12</td>
<td>19.2%</td>
<td>16.1%</td>
<td>-3.1%</td>
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<tr>
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<td>13.1%</td>
<td>-0.4%</td>
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<tr>
<td>Newark, NJ</td>
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<td>15</td>
<td>-6</td>
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<td>1.3%</td>
<td>-2.3%</td>
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<tr>
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<td>-11</td>
<td>4.3%</td>
<td>1.7%</td>
<td>-2.6%</td>
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<tr>
<td><strong>Total WA</strong></td>
<td>35</td>
<td>23</td>
<td>-12</td>
<td>14.9%</td>
<td>10.8%</td>
<td>-4.1%</td>
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</table>

![Decline in Average Distance to Serve Customer](chart.png)
Results: Mixed Integer Linear Programming (MILP)

MILP model identifies the optimal combination of locations that leads to the minimum total costs.

Summary

- Concentration of demand is indicated by heat maps
- Recommended sites and flows in each of the five markets is displayed. Existing facilities are included

- cross-docking facility
- customer node (5-digit zip code)
Results: Volume Allocation

Capacity utilization estimation reveals how recommended cross-docking facilities handle seasonal demand.

- Graph depicts the four total facilities in California, including the existing facilities
- **Average utilization is ~82%** for the three facilities carrying the most demand
- During the holiday peak, utilization rate **exceeds 100%; outsource or offload** to another facility
- Stratford facility is underutilized. The company could look for a smaller space, or it may be a good location to **shift demand** during times like the peak season

Summary
Results: Financial Impact

Compared to the baseline, the unconstrained MILP resulted in a 34% cost reduction, while including existing facilities led to a 23% cost reduction, when doubling the total facilities in the network.

Summary

- The second scenario reflects a more realistic operating footprint because existing facilities remain operational.
- This financial analysis is simplified; only transportation and leasing costs are included.
- Cost reduction estimates indicate directional accuracy. New facilities offer operational efficiency and cost savings.
- More inclusive cost analysis should be done as next step before finalizing network modeling decision.
Results: Break-even Analysis

Estimated transportation savings were calculated as the reduced mileage times the cost per mile. If the market transportation rate increased, the calculated savings would be greater with same distance reduction.

<table>
<thead>
<tr>
<th>$/SqFt/Yr</th>
<th>Baseline</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
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<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Average</td>
<td>Breakeven</td>
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<tr>
<td>Atlanta</td>
<td>$5.94</td>
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<tr>
<td>Dallas</td>
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<tr>
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<tr>
<td>NY / NJ</td>
<td>$23.57</td>
<td>$9.81</td>
<td>$25.67</td>
</tr>
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</table>

Summary

- MILP model allocates facilities **nearest** to dense demand to reduce the distance to service the customer.
- The **higher the transportation cost rates**, the **greater the incentive** to invest in additional facilities.
- The break-even unit cost for stations is the **benchmark** for the commercial buildings sourcing. Any unit cost lower than the ceiling would lead to an overall logistics cost (transportation and facility operation cost) savings.
Limitations and Suggestions to Further the Study

Limitations

- Other operational costs are not included in this study
- The nature of dynamic, market-based leasing rates is not captured in the model
- Demand is in a fast growing stage; the most recent peak period is not captured

Suggestions

1. Capacity planning based on most recent peak-season shipment data
2. Form cross-functional team to discuss strategic network decision: comprehensive real-estate study, network complexity, IT systems changes, retail partners willingness to change
Thank you