Characterization of Construction Materials Supply and Demand in an Urban Market

a proposal for a capstone project in partial fulfillment of the requirements for the degree of Master of Geographic Information Systems at The Pennsylvania State University

Chris DiMaggio
GEOG 596A
December 17, 2014

Faculty adviser: Kirby Calvert, Ph.D.
Objectives

✓ Develop a decision-support tool for evaluation of a new business venture:

1) Optimize the number and location of sales outlets
2) Estimate sales volumes at proposed outlets
3) Estimate network business volumes
4) Estimate cannibalization across the supplier’s network
5) Assess impacts of competitors
6) Assess impacts on competitors
7) Estimate resulting market shares

✓ Generalize this tool for application in other markets and business lines

✓ Adapt a GIS-based site selection model to an alternative demand model

1) Demand is discrete rather than continuous
2) Demand is based on events rather than demographics
Outline of presentation

I. Construction materials in an urban market defined
   A. Recycled aggregates
   B. Business strategies for recycled aggregate production
   C. A need for a more customized GIS-based demand model

II. Site selection modeling
   A. Analog models
   B. Regression models
   C. Location-allocation models
   D. Gravity models
   E. Spatial interaction models

III. Application of a spatial interaction model to Los Angeles, California
   A. Candidate site selection
   B. GIS-based demand model customization
      1. “Advanced Huff Model” (ArcGIS Business Analyst)
      2. Flater model
      3. Drezner optimization model
Construction materials in an urban market

Per capita aggregate consumption in Los Angeles County (tons)

- tons
- tons (trend)
Recycled aggregates: a case study from Chicago

• Recycled aggregates grew from 10% of the aggregates market in 2000 to nearly 30% today.
• Recycled aggregate consumption actually **increased** during the latest recession.

![Graph showing recycled aggregates consumption over years](image_url)

**SOURCE:** TOM KUECKER, 08/21/14
Population growth in the next five years will be concentrated in areas far from the supplier’s existing outlets.

- Hollywood & Downtown
- Mid-City
- Ports


Legend:
- Blue: -39 - 430
- Green: 431 - 713
- Yellow: 714 - 1008
- Orange: 1009 - 1578
- Red: 1579 - 7342

Supplier's plants indicated by stars.
Large future projects are concentrated in the urban core.
Business strategies for recycled aggregate production

5-10 acre pop-up storefronts that leverage a “dual-haul” strategy
Analyze the feasibility of a network of temporary ‘pop-up’ outlets for aggregate distribution, crushing, CCDD recycle, return concrete, landfill intake, and truck parking.

Business strategies for recycled aggregate production
Existing GIS-based demand models are insufficient
Existing GIS-based demand models are insufficient
Demand for construction materials in Beverly Hills

BUILT-OUT URBAN AREA: DEMAND NEARLY ZERO

NEW HOTEL: DEMAND 25,000 TONS
Models for retail site selection

1. Analog models

2. Regression models

3. Location-allocation models

4. Gravity models

5. Spatial interaction models
Spatial interaction model

\[ P_{ij} = \left( \prod_{h=1}^{H} A_{nj}^{\gamma_h} \right) D_{ij}^{\lambda} / \sum_{j=1}^{n} \left( \prod_{h=1}^{H} A_{nj}^{\gamma_h} \right) D_{ij}^{\lambda} \]
Spatial interaction models have seen limited integration in GIS software

ArcGIS Business Analyst “Advanced Huff Model”

Flater Model (ArcGIS Network Analyst & Spatial Analyst)

Drezner Model (VBA script in Excel)
Data requirements

**SELECT CANDIDATE PLANT SITES**

Criteria:
1. Minimum area = 5 acres
2. Study area: bounded by I-605 on east, I-10 on north, Pacific Ocean on west and south
3. “Industrial” zoning

Sources:
1. Los Angeles County parcel database
2. City zoning feature classes

**GEOCODE SUPPLIER & COMPETITOR PLANT LOCATIONS**

(ModelInfo)

**MODEL DEMAND EVENTS**

1. Select McGraw-Hill Construction projects meeting the following criteria:
   1. Located within study area
   2. In design or pre-design stage of development
   3. Budget exceeds $10 million
2. Geocode demand events

**CALIBRATE Huff MODEL PARAMETERS USING CUSTOMER SURVEY DATA**

<table>
<thead>
<tr>
<th>Utility Driver</th>
<th>Supplier</th>
<th>Competitive #1</th>
<th>Competitive #2</th>
<th>Competitive #3</th>
<th>Other suppliers</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical price and fees</td>
<td>3.37</td>
<td>3.85</td>
<td>3.21</td>
<td>3.26</td>
<td>3.26</td>
<td>3.95</td>
</tr>
<tr>
<td>Delivery (city and rural)</td>
<td>3.40</td>
<td>3.21</td>
<td>3.14</td>
<td>3.25</td>
<td>3.27</td>
<td>11.98</td>
</tr>
<tr>
<td>Availability (producer market)</td>
<td>3.66</td>
<td>3.65</td>
<td>3.24</td>
<td>3.93</td>
<td>4.25</td>
<td>9.80</td>
</tr>
<tr>
<td>Past response time to win availability</td>
<td>3.50</td>
<td>3.95</td>
<td>3.31</td>
<td>3.51</td>
<td>3.78</td>
<td>11.81</td>
</tr>
<tr>
<td>Ease and accuracy of chart placement (speed)</td>
<td>3.75</td>
<td>3.41</td>
<td>2.50</td>
<td>3.63</td>
<td>3.27</td>
<td>7.17</td>
</tr>
<tr>
<td>Total (Huff model)</td>
<td>2.25</td>
<td>2.26</td>
<td>2.37</td>
<td>2.23</td>
<td>2.26</td>
<td>7.08</td>
</tr>
<tr>
<td>Specifications and compatibility of products</td>
<td>4.60</td>
<td>4.95</td>
<td>3.31</td>
<td>3.79</td>
<td>3.29</td>
<td>6.14</td>
</tr>
<tr>
<td>Supplier reputation</td>
<td>3.75</td>
<td>3.18</td>
<td>3.68</td>
<td>3.77</td>
<td>3.65</td>
<td>6.14</td>
</tr>
<tr>
<td>Reliability/satisfaction</td>
<td>3.65</td>
<td>3.72</td>
<td>3.57</td>
<td>3.43</td>
<td>3.74</td>
<td>5.86</td>
</tr>
<tr>
<td>Repeatability/satisfaction</td>
<td>3.88</td>
<td>3.70</td>
<td>3.23</td>
<td>3.23</td>
<td>3.74</td>
<td>5.23</td>
</tr>
<tr>
<td>Convenience of placing order</td>
<td>3.87</td>
<td>3.87</td>
<td>3.36</td>
<td>3.36</td>
<td>3.74</td>
<td>5.86</td>
</tr>
<tr>
<td>Outage agreement index</td>
<td>3.87</td>
<td>3.88</td>
<td>3.53</td>
<td>3.33</td>
<td>3.56</td>
<td>4.66</td>
</tr>
<tr>
<td>Average/Unfair treatment</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
<td>3.50</td>
<td>4.51</td>
</tr>
<tr>
<td>Timeliness of shipping</td>
<td>4.67</td>
<td>4.60</td>
<td>3.87</td>
<td>3.73</td>
<td>3.65</td>
<td>3.93</td>
</tr>
</tbody>
</table>

**RUN MODELS**
Process and timeline

1. SELECT CANDIDATE SITES
2. GEOCODE SUPPLIER & COMPETITOR PLANT LOCATIONS
3. MODEL DEMAND EVENTS

CALIBRATE HUFF MODEL PARAMETERS USING CUSTOMER SURVEY DATA

\[ P_y = \left( \prod_{i=1}^{N} A_{y_i}^{k_i} \right) D_y \sum_{i=1}^{N} \left( \prod_{j=1}^{M} A_{y_j}^{k_j} \right) D_j \]

RUN MODELS

Calculate business volumes, cannibalization impacts and market shares under multiple scenarios

Model convergence and optimization

1. Identify optimal solution.
2. Generalize to supplier’s other markets and business lines (and develop Python scripting tool)

URISA GIS-Pro 2015
October 18-22, 2015
Spokane, Washington
Acknowledgments

Kirby Calvert, Ph.D.
Beth King
Mike Mrsa
Sidney Mays
Tom Kuecker
Bob Sears
Stephanie Formhals
\[ P_{ij} = \left( \prod_{h=1}^{H} A_{hj}^{\gamma_h} \right) D_{ij}^{\lambda} / \sum_{j=1}^{n} \left( \prod_{h=1}^{H} A_{hj}^{\gamma_h} \right) D_{ij}^{\lambda} \]