Warehouse Location Choice
A Case Study in Los Angeles, California, USA

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10/19/2017
Summary of this Paper

Purpose, Framework, & Key Findings
Summary of this Paper

- **Purpose**
  - To understand how / why warehouses have decentralized over time
  - To examine location choice of warehouse owners and developers

- **Framework**
  - A case study of warehouse location choice in Los Angeles, CA
  - Comparison of firm location choice factors over time

- **Key Findings**
  - The logic of location choice has changed over time
  - Warehouse location choice varies by facility size
  - Logistics costs rebalanced – facility and transport costs
Warehousing Decentralization
Definition – W&D Decentralization

☑ Warehousing and Distribution Centers
  ▪ A firm/facility that provides warehousing and logistics services
  ▪ An intermediary that connects supply chains
  ▪ Part of the logistics industry

☑ Warehousing Decentralization
  ▪ A shift in location from central areas to suburban/exurban areas
  ▪ Clustering of activities in a small number of clusters
Warehouse Data

- **CoStar**
  - Industrial real estate listings
  - Warehouses, truck terminals, distribution centers, or cold storages
  - Address, rentable building area (RBA), year of construction, etc.
  - No records of currently unavailable facilities; no way to construct an historical inventory of warehousing
  - Thus, a cross-sectional evaluation of existing warehouses (2016)

- **What we have:**
  - 5,364 facilities in Los Angeles, CA
  - Building Area > 30,000 ft²
  - Year of construction between 1951 and 2016
Sample Distribution

5,364 Warehouses in 2016

Sources: Esri, DeLorme, USGS, NPS, Sources: Esri: USGS/NOAA
Previous Warehouse Activity

Warehouses built between 1951 and 1980

- Downtown Los Angeles
- Traditional Industrial Areas
- Santa Monica
- Port vicinity
- Port of Los Angeles
- Port of Long Beach
- Irvine
- Ontario

- Seaports
- Cargo-Service Airports
- Intermodal Facilities
Recent Activity

Warehouses built between 2001 and 2016

Decentralization away from central areas & Concentration in The Inland Empire

- Irvine
- Santa Monica
- Ontario
- Los Angeles

△ Seaports
◆ Cargo-Service Airports
◆ Intermodal Facilities

Sources: Esri, DeLorme, USGS, NPS. Sources: Esri: USGS/NOAA/NCEP"
Why do location patterns change?

- Logistics restructuring
  - Globalized, geographically dispersed supply chains
  - Access to global markets – Proximity to trade infrastructure
  - Advanced transport technology – Reduced transport costs
  - Advanced logistics technology – Centralized inventory management, instant response, short dwell time

- More modernized and larger warehouses
  - To transport large volumes of goods quickly, cheaply, and reliably

- Main driver: Land price and availability
  - Lower land prices, larger parcels, favorable business environment
Why should we care?

- Significant growth over the last decade
  - Warehousing jobs 33% ↑ vs. All US jobs 4% ↑
  - US Foreign trade 40% in $ ↑ vs. US population 10% ↑

- Warehouses as truck trip generators
  - If warehouses are located farther from markets, Truck travel distance would increase; Impact would increase

- Negative externalities
  - Congestion, fuel consumption, air pollution
  - Noise, vibration, infrastructure damage
  - Environmental justice
What do we know?

- Changes in warehouse distribution
  - Warehouses have/have not changed location – Atlanta, LA, Paris, Tokyo, Toronto, Seattle... Etc.

- Shifts in location choice
  - Known: cross-section warehouse location choice factors
  - Unknown: whether the location choice logic has changed

- Factors for decentralization
  - Known: only theoretical discourse so far; no systematic testing
  - Limited data, limited sample, limited methodology
Research Approach

Questions, Findings, and Contributions
To examine changes in sub-metropolitan location factors to understand how and why warehouse owners/developers have made different location decisions over time

1. Evaluate changes in location factors over time
2. Evaluate changes in location factors by facility size
3. Examine logistics cost tradeoffs
Research Approach

▪ Rationale
  ▪ Warehouses seek productivity-enhancing location attributes.
  ▪ Through logistics restructuring,
  ▪ the characteristics of warehousing facilities have changed,
  ▪ specific location requirements arose,
  ▪ facility location changed to fulfill new operation goals.

▪ Structure – firm location choice (random utility)
  ▪ The choice of a location entails an unobservable profit $X$
  ▪ Facility and Location characteristics jointly influence the profit
  ▪ Choice of A over B is made if/only if Profit A > Profit B
  ▪ $P_n(j) = f(location, facility)$; Multinomial logit model
Research Approach

- **Design**
  - Logistics restructuring: technology/operation changed over time
    - cost structure and location change
    - To compare warehouse location factors across time periods
  - Facility size influences cost structure and location choice
    - To use an interaction dummy of facility size
  - Location factors
    - land prices, proximity to local market and trade nodes, labor force

- **Choice set**
  - Universal choice set: 660 census tracts with at least one warehouse
  - Actual choice + 9 random alternatives = 10 choice alternatives *

*With the IIA assumption, parameters can be consistently estimated using only a subset of the alternatives from the universal choice set (McFadden, 1978; Pozsgay and Bhat, 2002; Scott and He, 2012).*
## Location Factors

<table>
<thead>
<tr>
<th>Location factors</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land price</td>
<td>Population and employment densities in 2010, as proxies</td>
</tr>
<tr>
<td></td>
<td>(Clark, 1951; McDonald, 1989)</td>
</tr>
<tr>
<td>Labor force access</td>
<td>Sum of population (2010) with an inverse travel-time weight within 30 min driving distance</td>
</tr>
<tr>
<td>Proximity to local markets</td>
<td>Driving time to the nearest employment sub-centers</td>
</tr>
<tr>
<td></td>
<td>(Giuliano and Small, 1991)</td>
</tr>
<tr>
<td>Proximity to Transport nodes</td>
<td>Driving time to the nearest airport, seaport, intermodal terminals</td>
</tr>
<tr>
<td></td>
<td>Distance to the nearest highway ramps</td>
</tr>
</tbody>
</table>

*Travel time is calculated based on the SCAG Regional Transportation Plan 2012 database Using ArcGIS Network Analysts*
### Sample Distribution and ML Model

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>30-100k (small)</td>
<td>1,604 (29.9%)</td>
<td>1,311 (24.4%)</td>
<td>578 (10.8%)</td>
<td>3,493 (65.1%)</td>
</tr>
<tr>
<td>100-300k (medium)</td>
<td>528 (9.8%)</td>
<td>554 (10.3%)</td>
<td>309 (5.8%)</td>
<td>1,391 (25.9%)</td>
</tr>
<tr>
<td>Over 300k (large)</td>
<td>61 (1.1%)</td>
<td>157 (2.9%)</td>
<td>262 (4.9%)</td>
<td>480 (8.9%)</td>
</tr>
<tr>
<td>Sum</td>
<td>2,193 (40.9%)</td>
<td>2,022 (37.7%)</td>
<td>1,149 (21.4%)</td>
<td>5,364 (100%)</td>
</tr>
</tbody>
</table>

- **Model 1**: Compare results between periods 1, 2, and 3 *
  - **Without** building size interaction dummy
- **Model 2**: Compare results between periods 1, 2, and 3 *
  - **With** building size interaction dummy

* Formal testing of the difference between the estimated parameters is based on Allison (1999)
## Sample Distribution and ML Model

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<tr>
<td>2,790-9,290 m²</td>
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  - **Without** building size interaction dummy
- **Model 2**: Compare results between periods 1, 2, and 3
  - **With** building size interaction dummy
Sample Distribution

By built year

Ontario
San Bernardino, Riverside, Moreno Valley

By building area

Ontario
San Bernardino, Riverside, Moreno Valley
Results of Econometric Models
## Results of Models w/ interaction (1)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td></td>
<td>Coef.</td>
<td>Coef.</td>
<td>$\chi^2$</td>
<td>Coef.</td>
<td>$\chi^2$</td>
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<tr>
<td>Population density</td>
<td>-0.316</td>
<td>-0.398</td>
<td>11.593</td>
<td>-0.387</td>
<td>0.121</td>
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<tr>
<td>x Medium</td>
<td>-0.027</td>
<td>-0.013</td>
<td>0.099</td>
<td>-0.082</td>
<td>1.643</td>
</tr>
<tr>
<td>x Large</td>
<td>-0.071</td>
<td>-0.077</td>
<td>0.004</td>
<td>-0.046</td>
<td>0.171</td>
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<tr>
<td>Employment density</td>
<td>0.963</td>
<td>0.674</td>
<td>27.384</td>
<td>0.502</td>
<td>7.847</td>
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<tr>
<td>x Medium</td>
<td>0.064</td>
<td>0.034</td>
<td>0.075</td>
<td>-0.165</td>
<td>3.319</td>
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<tr>
<td>x Large</td>
<td>0.081</td>
<td>-0.034</td>
<td>0.223</td>
<td>-0.533</td>
<td>11.139</td>
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<tr>
<td>Labor force access</td>
<td>0.895</td>
<td>0.892</td>
<td>0.001</td>
<td>0.725</td>
<td>1.266</td>
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<tr>
<td>x Medium</td>
<td>-0.065</td>
<td>-0.018</td>
<td>0.278</td>
<td>0.184</td>
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<td>x Large</td>
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<td>-0.008</td>
<td>0.496</td>
<td>0.149</td>
<td>1.236</td>
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<tr>
<td>Prox. Local market</td>
<td>0.744</td>
<td>1.749</td>
<td>71.304</td>
<td>1.256</td>
<td>9.444</td>
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<tr>
<td>x Medium</td>
<td>0.354</td>
<td>0.565</td>
<td>0.841</td>
<td>0.570</td>
<td>0.000</td>
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<tr>
<td>x Large</td>
<td>0.092</td>
<td>1.242</td>
<td>4.486</td>
<td>-0.221</td>
<td>11.521</td>
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</table>

... table continued
### Results of Models w/ interaction (2)

<table>
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</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Coef.</td>
<td>χ²</td>
<td>Coef.</td>
<td>χ²</td>
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<tr>
<td>Prox. Airport</td>
<td>0.726</td>
<td>-0.497</td>
<td>125.946</td>
<td>-0.430</td>
<td>0.269</td>
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<tr>
<td>x Medium</td>
<td>0.505</td>
<td>-0.434</td>
<td>18.148</td>
<td>-0.226</td>
<td>0.878</td>
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<tr>
<td>x Large</td>
<td>0.520</td>
<td>-1.235</td>
<td>9.487</td>
<td>-0.677</td>
<td>3.080</td>
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<tr>
<td>Prox. Seaport</td>
<td>-0.466</td>
<td>1.031</td>
<td>154.510</td>
<td>1.604</td>
<td>9.674</td>
</tr>
<tr>
<td>x Medium</td>
<td>-0.098</td>
<td>-0.117</td>
<td>0.009</td>
<td>0.083</td>
<td>0.537</td>
</tr>
<tr>
<td>x Large</td>
<td>0.888</td>
<td>1.271</td>
<td>0.607</td>
<td>2.168</td>
<td>4.355</td>
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<tr>
<td>Prox. Intermodal</td>
<td>-0.286</td>
<td>-0.061</td>
<td>5.289</td>
<td>-0.278</td>
<td>2.965</td>
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<tr>
<td>x Medium</td>
<td>-0.625</td>
<td>-0.072</td>
<td>10.083</td>
<td>-0.344</td>
<td>1.792</td>
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<tr>
<td>x Large</td>
<td>-0.760</td>
<td>-0.555</td>
<td>0.277</td>
<td>-0.903</td>
<td>1.538</td>
</tr>
<tr>
<td>Prox. Highway</td>
<td>-0.011</td>
<td>0.062</td>
<td>2.427</td>
<td>0.110</td>
<td>0.520</td>
</tr>
<tr>
<td>x Medium</td>
<td>0.027</td>
<td>0.045</td>
<td>0.038</td>
<td>-0.098</td>
<td>1.579</td>
</tr>
<tr>
<td>x Large</td>
<td>-0.101</td>
<td>-0.274</td>
<td>0.763</td>
<td>-0.113</td>
<td>1.070</td>
</tr>
<tr>
<td>Log likelihood (null)</td>
<td>-7,129.1</td>
<td>-6,573.2</td>
<td>-3,735.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood (full)</td>
<td>-5,777.7</td>
<td>-5,283.7</td>
<td>-3,038.3</td>
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<td></td>
</tr>
<tr>
<td>Pseudo-R²</td>
<td>0.190</td>
<td>0.196</td>
<td></td>
<td>0.187</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2,193</td>
<td>2,022</td>
<td></td>
<td>1,149</td>
<td></td>
</tr>
</tbody>
</table>
Summary of Results

- Building size and Time (across models) significantly explain the variation in warehouse location choice
- Land price attributes work in opposite directions:
  - Effect of population, as a push factor, increased (medium W&D)
  - Effect of employment, as a pull factor, diminished (large W&D)
- Labor force access, significant and stable over time
- Proximity measures
  - Local market: (+) the farther, the more warehouses; high land price
  - Seaport: from (−) to (+); next to central urban areas
  - Airport: from (+) to (−); important periods 2 and 3
  - Intermodal: (−); consistently important for large W&Ds
  - Highways: insignificant/mixed; ubiquity of highways
Conclusions and Discussion

Planning Implications
Conclusions and Discussion

- Different location preferences by facility size and time period
- W&Ds built in 2001-2016
  - Potential savings in facility and inventory costs from lower land prices, economies of scale, and inventory consolidation
  - Savings in transport costs are unclear
    - movement from local markets to trade nodes
    - Saving depends on the function of a facility (unknown)
- Will this pattern of development continue?
  - From throughput to speed
  - Warehouse management system and online shopping focus on delivery speed (access to local markets and trade nodes)
References (only those mentioned in the presentation)

Thank you!

Warehouses have been established on the urban peripheries to transport large volumes of goods cheaply and reliably.

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