Unraveling decentralization of warehousing and distribution centers
A case study of four metropolitan areas in California
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Logistics Industry Expansion & Supply Chain Restructuring

Factors driving restructuring:
- Economies of Scale
- Advanced info-com-tech
- Advanced transport-tech
- Access to supply chain
- Customer-driven goods production systems
- E-commerce
- Increasing share of high value/low weight goods

W/DC Industry Restructuring Goal:
- High throughput
- Velocity
- Reliability

Geographically Extensive Supply Chains:
- Suppliers-Producers-Distributors-Consumers
- System-wise integration
- Geographical separation
- Search for low costs
  - From 1970s
Metropolitan-level Supply Chain Restructuring

W/DC Industry Restructuring Goal
- High throughput
- Velocity
- Reliability

Location Factor Trade-offs
- Parcel/Facility size $\uparrow$
- Inventory costs $\downarrow$
- Flexible travel distance $\uparrow$
- Access to local market $\downarrow$

Location Implication
- ‘To the urban periphery’
- Tradeoffs suggest decentralization.
Location Implication

‘To the urban periphery’

Tradeoffs suggest decentralization

Why is this a planning issue?

• Growing volume of freight in metro areas
• Growing concerns about potential negative externalities
• on communities
Location Implication

‘To the urban periphery’

Tradeoffs suggest decentralization

Research Gap?

• What factors explain warehousing decentralization?
• Then, what about truck activities?
• Empirical testing?
• Modeling, simulation?
Research Questions

“How do we systematically measure changes in warehousing location?”

“Are there consistent trends?”
A (very simplified) metro area

- CBD
- High density urban core
- Urban area
1 market – 1 warehouse – 1 port

High density urban core

Urban area

CBD → WDC

W/DC: warehousing and distribution center

Freight Node
Decentralizing warehouses?

High density urban core

Urban area

2003

CBD

WDC

WDC

WDC

WDC

WDC

Freight Node
Decentralizing warehouses?

High density urban core

Urban area 2008
Decentralizing warehouses?

High density urban core

Urban area 2013

CBD

WDC

Freight Node
Concentrating warehouses?

- High density urban core
- Urban area
- 2013

Industrial Zoning, suitable for warehousing

- Cargo service airport
- Freight Node
Empirical Evidence

• Increased distance from the W/DC geographic center
  • “Decentralization” “Logistics Sprawl”
  • Los Angeles, 1998-2009 (Dablanc et al., 2014)
  • Atlanta, 1998-2008 (Dablanc and Ross, 2012)
  • 14 UK metro areas, 1998-2008 (Allen, Browne, and Cherrett, 2012)

• Decreased distance from the W/DC geographic center
  • “Centralization”
  • Seattle, 1998-2009 (Dablanc et al., 2014)

• Decreased Gini coefficient
  • “Dispersion”

• Increased Gini coefficient
  • “Concentration” “Clustering”
  • Provinces of the Netherlands, 1996-2009 (Van den Heuvel et al., 2013)
## Research Approach - Spatial measures

<table>
<thead>
<tr>
<th>Spatial Structure</th>
<th>Of W/DCs</th>
<th>With respect to Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of W/DC employment</td>
<td>Of W/DC employment</td>
<td>With respect to Population</td>
</tr>
</tbody>
</table>

### Measure of Centrality

#### Measure 1.
**Decentralization**

- **Average distance**
  - from CBD
  - to freight nodes
  - from W/DC geographic center

#### Measure 2.
**Relative decentralization**

- **Average distance**
  - to all employment
  - to all population

### Measure of Concentration

#### Measure 3.
**Concentration**

- **Gini coefficient for W/DCs**

- **Proportion of W/DCs by Employment density quartiles**

#### Measure 4.
**Relative concentration**

- **Gini coefficient difference, W/DCs and all employment**
Data

• ZIP code Business Patterns (ZBP) 2003-2013
  • Developed/maintained by Census
  • N of establishment available
  • Employment imputation by quadratic programming
  • Centroids at the locations with the highest concentration of activities
  • ZIP code size varies by development density

• Warehouses? (W/DCs)
  • NAICS 493 Warehousing and storage
  • Facilities that store goods, and/or provide logistics services

• Case study areas
  • Four metro areas in California
    • Los Angeles CSA, San Francisco CSA, Sacramento CSA, San Diego MSA
  • Vary in size, industry mix and role in global economy
## Case study areas: W/DC Industry and Employment

<table>
<thead>
<tr>
<th>Year</th>
<th>Los Angeles CSA</th>
<th>San Francisco CSA</th>
<th>Sacramento CSA</th>
<th>San Diego MSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Employment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>18 M</td>
<td>7 M</td>
<td>3 M</td>
<td>2.5 M</td>
</tr>
<tr>
<td>2013</td>
<td>7 M</td>
<td>3 M</td>
<td>1 M</td>
<td>1 M</td>
</tr>
<tr>
<td>Area (sqkm)</td>
<td>88 K</td>
<td>18 K</td>
<td>11 K</td>
<td>19 K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>775</td>
<td>34,333</td>
<td>257</td>
<td>9,603</td>
<td>80</td>
<td>3,699</td>
<td>84</td>
<td>1,650</td>
</tr>
<tr>
<td>2013</td>
<td>1,001</td>
<td>49,266</td>
<td>311</td>
<td>11,476</td>
<td>143</td>
<td>5,641</td>
<td>86</td>
<td>1,720</td>
</tr>
</tbody>
</table>

%Δ  

| %Δ | 29% | 43% | 21% | 20% | 79% | 52% | 2% | 4% |
## Results: M1 Decentralization

<table>
<thead>
<tr>
<th>Metro area</th>
<th>Measure 1-1 Average distance from</th>
<th>Measure 1-2 Average distance to freight nodes</th>
<th>Measure 1-2 Average distance to freight nodes</th>
<th>Measure 1-2 Average distance to freight nodes</th>
<th>Measure 1-3 Average distance from W/DC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CBD</td>
<td>Airport</td>
<td>Intermodal</td>
<td>Seaport</td>
<td>Geo-Center</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>++</td>
<td>++++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>San Francisco</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Sacramento</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>San Diego</td>
<td>-</td>
<td>+++</td>
<td>-</td>
<td>+++</td>
<td>-</td>
</tr>
</tbody>
</table>

* Welch’s t-test for statistical significance (unpaired, unequal variance)
# Results: M2 Relative Decentralization

<table>
<thead>
<tr>
<th>Metro area</th>
<th>Measure 2-1</th>
<th></th>
<th>Measure 2-2</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Employment</td>
<td></td>
<td>All Employment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>W/DCs</td>
<td>W/DC Emp.</td>
<td>W/DCs</td>
<td>W/DC Emp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes 2003-2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Francisco</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sacramento</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Diego</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*W/DCs: With DCs  W/DC Emp.: With DC Employment*
## Results: M3 Concentration

<table>
<thead>
<tr>
<th>Metro area</th>
<th>Measure 3-1 Gini Coefficient</th>
<th>Measure 3-2 W/DC concentration in the 1&lt;sup&gt;st&lt;/sup&gt; Employment density Quartile</th>
<th>Measure 3-2 W/DC concentration in the 2&lt;sup&gt;nd&lt;/sup&gt; Employment density Quartile</th>
<th>Measure 3-2 W/DC concentration in the 3&lt;sup&gt;rd&lt;/sup&gt; Employment density Quartile</th>
<th>Measure 3-2 W/DC concentration in the 4&lt;sup&gt;th&lt;/sup&gt; Employment density Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>San Francisco</td>
<td>+ -</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Sacramento</td>
<td>- ++</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>- - -</td>
</tr>
<tr>
<td>San Diego</td>
<td>++++ ++</td>
<td>-</td>
<td>0</td>
<td>++</td>
<td>-</td>
</tr>
</tbody>
</table>

*Gini: Jackknife standard error for statistical significance*
# Results: M4 Relative Concentration

<table>
<thead>
<tr>
<th>Metro area</th>
<th>Gini coefficient difference, W/DCs and all employment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Changes 2003-2013</strong></td>
<td><strong>W/DC Emp.</strong></td>
</tr>
<tr>
<td>Los Angeles</td>
<td>+++</td>
</tr>
<tr>
<td>San Francisco</td>
<td>++</td>
</tr>
<tr>
<td>Sacramento</td>
<td>++++</td>
</tr>
<tr>
<td>San Diego</td>
<td>+++</td>
</tr>
</tbody>
</table>
Discussion

1. How you measure matters.

2. Little evidence of consistent W/DC decentralization across four metropolitan areas.
   1. LA: decentralization + concentration true for all measures
   2. SF: weak decentralization
   3. SC: dispersed centralization
   4. SD: clustered centralization

3. Trends are consistent over time period.

4. Multiple measures provide more information on the nature of the spatial change.

5. Employment seems more flexible with respect to spatial change than establishment.
Results: M1 Decentralization

Measure 1-1 Average distance from CBD

Measure 1-3 Average distance to Geo-center
Discussion

1. How you measure matters.

2. Little evidence of consistent W/DC decentralization across four metropolitan areas.
   1. LA: decentralization + concentration true for all measures
   2. SF: weak decentralization
   3. SC: dispersed centralization
   4. SD: clustered centralization

3. Trends are consistent over time period.

4. Multiple measures provide more information on the nature of the spatial change.

5. Employment seems more flexible with respect to spatial change than establishment.
N of W/DC employment by ZIP code in 2003
Discussion

1. How you measure matters.

2. Little evidence of consistent W/DC decentralization across four metropolitan areas.
   1. LA: decentralization + concentration true for all measures
   2. SF: weak decentralization
   3. SC: dispersed centralization
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5. Employment seems more flexible with respect to spatial change than establishment.
Future Research

1. Factors that explain W/DC decentralization
   • Land rent – density, elasticity
   • Global supply chain engagement
   • Local market size – industry size and composition
   • Local labor market
   • Land use and tax policy
   • Population characteristics
   • Congestion and delay

2. The effect of W/DC decentralization on metropolitan truck activity
   • Simulation and modeling
Reference


