Spatial distribution of logistics facilities and truck traffic

Kazuya Kawamura
Takanori Sakai
Tetsuro Hyodo

CMAP Freight Committee
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Logistics sprawl
Logistics sprawl

“historical trend towards spatial deconcentration of logistics terminals in metropolitan areas”

_Dablanc & Rakotonarivo (2010)_
Logistics sprawl

“historical trend towards spatial deconcentration of logistics terminals in metropolitan areas”

Dablanc & Rakotonarivo (2010)

Locations of selected parcel delivery cross-docking facilities in the Paris region (1974-2008)
Traffic Impacts of Logistics sprawl

Mean distance of delivery cross–docking facilities to the Paris center increased from 6km to 16km

→ 10km increase in VMT for shipments to Paris core area
→ Estimated increase in CO$_2$ = 15,000 tons/yr (93 terminals)
Subsequent studies identify wide-spread logistics sprawls in Europe and US

- **Atlanta**: Dablanc and Ross (2012)
- **Paris**: Heitz and Dablanc, (2015)
- **Toronto**: Woudsma et al., (2016)
- **Zurich**: Todesco et al., (2016)
- **Los Angeles**: Dablanc et al., (2014)
- **Seattle**: Dablanc et al., (2014)
Transportation & warehousing employment 1990

# in Industry: Transportation, 1990 by Census Tracts

- 0 - 27
- 28 - 46
- 47 - 64
- 65 - 80
- 81 - 99
- 100 - 122
- 123 - 151
- 152 - 200
- 201 - 1,166
Transportation & warehousing employment 2010

# Employment, Transportation and Warehousing, 2010 by Census Tracts

- 0 - 20
- 21 - 42
- 43 - 63
- 64 - 82
- 83 - 106
- 107 - 133
- 134 - 166
- 167 - 218
- 219 - 1,390
Many transportation planners are concerned about the negative impacts of logistics sprawl

→ Increase in truck vehicle miles traveled (VMT)
  - Congestion
  - Carbon emission
  - Air pollution

How can we bring logistics back into cities? The case of Paris metropolitan area

Logistics Sprawl Assessment Applied to Locational Planning: A Case Study in Palmas (Brazil)

Articles
Beyond ‘logistics sprawl’ and ‘logistics anti-sprawl’. Case of the Katowice region, Poland
Robert Krzysztofik, Iwona Kantor-Pietruga, Tomasz Spórna, Weronika Dragan, & Valentin Mihaylov
But, only one existing study looked at truck traffic impact of logistics sprawl

*Paris crossdocking facility in 2010*
Research questions

1. How does logistics sprawl affect truck VMT?
2. What is the appropriate land use policies to reduce truck VMT?

A series of papers 2015-2019
Data 2003 & 2013 Tokyo Metropolitan Freight Survey

2013: Targeted 136,632 total establishments and 43,131 responded (31.6 % resp. rate).

4,580 logistics facilities with 2,147 facilities (11% of all logistics facilities in the TMA) provided complete shipment records.

Expansion factors based on location, employment size, facility type.
In our definition, logistics facilities (LF) include distribution centers, truck terminals, warehouses, intermodal facilities and oil terminals.
2003: 25.7 km
2013: 32.3 km

Avg. distance of logistics facilities from the urban center
Quintiles (QUs) of the distance (km) from the urban center for urban structure indicators and logistics facilities

<table>
<thead>
<tr>
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<td>Establishments</td>
<td>9.0</td>
<td>18.4</td>
<td>32.1</td>
<td>48.2</td>
<td>9.7</td>
<td>19.3</td>
<td>32.7</td>
<td>48.0</td>
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<tr>
<td></td>
<td>(+0.7)</td>
<td>(+0.9)</td>
<td>(+0.6)</td>
<td>(-0.2)</td>
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<tr>
<td>Population</td>
<td>15.4</td>
<td>25.6</td>
<td>36.4</td>
<td>49.2</td>
<td>15.1</td>
<td>24.9</td>
<td>35.6</td>
<td>48.2</td>
</tr>
<tr>
<td></td>
<td>(-0.3)</td>
<td>(-0.7)</td>
<td>(-0.8)</td>
<td>(-1.0)</td>
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<tr>
<td>Factories</td>
<td>12.0</td>
<td>20.4</td>
<td>35.4</td>
<td>50.6</td>
<td>14.6</td>
<td>24.1</td>
<td>40.2</td>
<td>54.5</td>
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<tr>
<td></td>
<td>(+2.6)</td>
<td>(+3.7)</td>
<td>(+4.8)</td>
<td>(+3.9)</td>
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<td></td>
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<tr>
<td>Shipment demands</td>
<td>10.9</td>
<td>20.5</td>
<td>33.9</td>
<td>49.7</td>
<td>14.2</td>
<td>25.8</td>
<td>38.4</td>
<td>51.7</td>
</tr>
<tr>
<td></td>
<td>(+3.3)</td>
<td>(+5.3)</td>
<td>(+4.5)</td>
<td>(+2.0)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Logistics facilities</td>
<td>8.2</td>
<td>15.4</td>
<td>27.2</td>
<td>41.5</td>
<td>13.4</td>
<td>23.2</td>
<td>35.2</td>
<td>48.2</td>
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<tr>
<td></td>
<td>(+5.2)</td>
<td>(+7.8)</td>
<td>(+8.0)</td>
<td>(+6.7)</td>
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</table>

Decentralization of logistics facilities is on par with decentralization of factories and shipment demands.
### All LFs in the study area

<table>
<thead>
<tr>
<th></th>
<th>Average shipment distance (km)</th>
<th>Total truck-km-traveled (mil.)</th>
<th>Truck-km-traveled per tons handled by LFs</th>
<th>Total truck trips (thou.)</th>
<th>Average load (ton/truck trip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>34.9</td>
<td>23.7</td>
<td>20.5</td>
<td>680</td>
<td>2.72</td>
</tr>
<tr>
<td>2013</td>
<td>37.1</td>
<td>19.3</td>
<td>19.6</td>
<td>520</td>
<td>3.10</td>
</tr>
<tr>
<td>Change</td>
<td>+6%</td>
<td>-19%</td>
<td>-4%</td>
<td>-24%</td>
<td>+14%</td>
</tr>
</tbody>
</table>

While avg. shipment distance increased, truck VMT decreased (by 19%!)
• Manufacturing left Tokyo → less freight overall
• Load size increased → less number of trips
Is larger average load enabled by logistics sprawl?
Distance to urban center vs. truck shipment load size

Association between load size and distance from the urban center is mostly consistent regardless of age of facility.
Observations

- Logistics sprawl does not necessarily increase truck VMT
- Relationship between truck VMT and location of logistics facilities is complex
- Factors: load size, shipment distance, shipment frequency, facility size, commodity type
Observations

• Logistics sprawl does not necessarily increase truck VMT
• Relationship between truck VMT and location of logistics facilities is complex
• Factors: load size, shipment distance, shipment frequency, facility size, commodity type

Is it possible to formulate effective land use policy for logistics facilities?
Land use policy analysis

- Used computer simulation to test various land use strategies
ULLTRA-SIM

2013 TMFS data set

Exogenous input
- Location data (accessibility, site characteristics, and zoning)
- Logistics facility data
- P and C counts (i.e. shipment demands)

Model/Simulator
1. Logistics Facility Location Choice Model
2. Logistics Chain Model
   2.1 Internal P-A & G-C pairing model
   2.2 A (for G→A trip) generation model
   2.3 Internal G-A pairing model
   2.4 External P-A & G-C pairing model
3. Traffic Flow and Impact Simulator
   3.1 Traffic assignment
   3.2 Impact estimation

Output at each step/Endogenous input
- Logistics facility locations
- Internal P→A and G→C trips
- A (for G→A trip) counts
- G→A trips
- External P→A and G→C trips
- Assigned traffic
- Externality indicators
Note: The simulation model does not include effect of location on shipment size.
Scenarios

(I) Baseline

(II) Shipment distance minimization

(IV) Decentralization

(V) Concentration

(VI) Deconcentration
<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Description</th>
<th>Mean of dist. to urban center (small, medium, large LFs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I) Baseline</td>
<td>No adjustment to model parameters or choice probabilities – best replication of 2013 Survey data</td>
<td>37.3 km 38.3 km 37.3 km</td>
</tr>
<tr>
<td>(II) Shipment distance minimization</td>
<td>All LFs are at the location that minimize sum of shipment distances (via feedback loop)</td>
<td>34.6 km 34.4 km 30.2 km</td>
</tr>
<tr>
<td>(III) Centralization</td>
<td>All LFs are at the urban center</td>
<td>0km, 0km, 0km</td>
</tr>
<tr>
<td>(IV Decentralization)</td>
<td>No LFs are allowed within 30 km from the urban center</td>
<td>48.6 km 49.0 km 50.8 km</td>
</tr>
<tr>
<td>(V) Concentration</td>
<td>Concentrates logistics facilities in the port area that has traditionally served as the major freight generator.</td>
<td>36.0 km 36.7 km 32.9 km</td>
</tr>
<tr>
<td>(VI) Deconcentration</td>
<td>Discourage LF to locate in Industrial zones and locations that are in the highest 0.5 % of employment accessibility and high population density.</td>
<td>40.4 km 40.7 km 42.6 km</td>
</tr>
</tbody>
</table>
### Scenario analysis results

<table>
<thead>
<tr>
<th></th>
<th>Total VKT [mil. km]</th>
<th>Total VHT [thou. hr]</th>
<th>Total CO₂ [thou. ton]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(I) Baseline</strong></td>
<td>Mean 26.9</td>
<td>560</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>SD 0.05</td>
<td>1.0</td>
<td>0.03</td>
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<tr>
<td><strong>(II) Distance minimization</strong></td>
<td>Mean 23.8</td>
<td>494</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td>SD 0.01</td>
<td>0.2</td>
<td>0.01</td>
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<td></td>
<td>Diff. from (I) -11.6%</td>
<td>-11.7%</td>
<td>-11.7%</td>
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<tr>
<td><strong>(III) Centralization</strong></td>
<td>Mean 27.8</td>
<td>568</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>SD -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Diff. from (I) +3.6%</td>
<td>1.3%</td>
<td>+4.1%</td>
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<tr>
<td><strong>(IV) Decentralization</strong></td>
<td>Mean 29.6</td>
<td>613</td>
<td>17.9</td>
</tr>
<tr>
<td></td>
<td>SD 0.06</td>
<td>1.0</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Diff. from (I) +10.2%</td>
<td>9.4%</td>
<td>+9.9%</td>
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<tr>
<td><strong>(V) Concentration</strong></td>
<td>Mean 26.6</td>
<td>554</td>
<td>16.2</td>
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<tr>
<td></td>
<td>SD 0.05</td>
<td>1.1</td>
<td>0.03</td>
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<tr>
<td></td>
<td>Diff. from (I) -1.1%</td>
<td>-1.1%</td>
<td>-0.8%</td>
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<tr>
<td><strong>(VI) Deconcentration</strong></td>
<td>Mean 27.4</td>
<td>571</td>
<td>16.6</td>
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<tr>
<td></td>
<td>SD 0.05</td>
<td>0.8</td>
<td>0.02</td>
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<td></td>
<td>Diff. from (I) +2.0%</td>
<td>1.9%</td>
<td>+1.9%</td>
</tr>
</tbody>
</table>
What we found

• Reality is complex

Facility-specific and variable characteristics (e.g. demand locations, commodity handled) have strong effects on truck VMT

Extremely challenging, if not impossible, to reduce truck VMT through land use policies
Thank you
• Kawamura, K., Sakai, T., & Hyodo, “Factors affecting the efficiency of truck usage and implications for logistics sprawl” under review