Modelling Freight Vehicle Type and Shipment Size Choice

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Freight Business and Logistics Decisions Simulation Framework

[Diagram showing the simulation framework with various decision nodes and connections between them, including New Business Establishment Choice, Establishment Location Choice, Logistics Strategy Decision, Commercial Vehicle Ownership, Commodity Generation, Commodity Contract Formation, Shipment Size Choice, Vehicle Type Choice, Carrier Type Choice, Carrier Choice, and Tour-Based Shipment Delivery.]
Freight Mode v/s Vehicle Type

➢ Mode Choice:
  • Road, rail, air, water
  • Most relevant for inter-city, statewide, and national level studies

➢ Vehicle Type Choice:
  • Road-based mode: Passenger car, trucks, vans, etc.
  • Most relevant for city or metropolitan area level studies
Background and Motivation

- Freight flows have been increasing in Canada.
  - 16.7% increase in freight shipments from 2011 to 2017 (Statistics Canada 2020)
- Economic development of regions
- Global competitiveness of industries
- Changing trends in supply chain and logistics
- Major contribution to greenhouse gas emissions!
Background and Motivation

- **Oil and Gas, 26%**
- **Transport, 25%**
- **Electricity, 8%**
- **Heavy Industry, 11%**
- **Buildings, 12%**
- **Agriculture, 10%**
- **Waste and Others, 7%**

Inner Circle:
- **Freight Transport, 42%**
- **Passenger Transport, 53%**
- **Other, 5%**

CLUE
Background and Motivation

- Implications on quality of life of urban residents
  - Noise pollution
  - Traffic congestion
  - Safety impacts
  - Parking problems
  - Pavement damage
Study Objectives

- Study the factors behind freight vehicle type and shipment size choice

- Comparison of independent v/s joint (correlated) choices
  - Substitution patterns
Data Source

- Commercial Travel Survey
  - Region of Peel (2006/07), Region of Durham (2010), Toronto Area (2012)

- Outbound Shipments
  - 1,019 shipments
  - 292 firms

- Explanatory Variables
  - Industry type, commodity type
  - Shipment origin and destination (cities)
  - Employment and shipment value
Data Source

Employment (Natural Logarithmic Scale)

Frequency
Methodology

Vehicle Type

- PC
  - S1
  - S2
  - S3
  - S4
- VAN
  - S1
  - S2
- SUT
  - S1
  - S2
  - S3
- TT
  - S1
  - S2
  - S3
  - S4

Shipment Size

- S1
  - PC
  - VAN
  - SUT
  - TT
- S2
  - PC
  - VAN
  - SUT
  - TT
- S3
  - VAN
  - SUT
  - TT
- S4
  - SUT
  - TT
Methodology

➢ Methods

• Sequential logit
• Nested logit
• Models developed for both structures
Results
Results

➢ Larger firms are more likely to use larger vehicles

➢ Intracity shipments are more likely to be transported using smaller vehicles

➢ Larger vehicles are more likely to be used for shipments destined outside of Toronto Area

➢ High density value shipments are more likely to be smaller in size and are transported using smaller vehicles
# Model Fit Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Vehicle – Shipment (VS)</th>
<th>Shipment – Vehicle (SV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nested Logit</td>
<td>Sequential Logit</td>
</tr>
<tr>
<td>Log-Likelihood (0)</td>
<td>-2613.68</td>
<td>-2659.68</td>
</tr>
<tr>
<td>Log-Likelihood (final)</td>
<td>-2150.16</td>
<td>-2118.31</td>
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<tr>
<td>$\rho^2$</td>
<td>0.18</td>
<td>0.20</td>
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<tr>
<td>Adjusted $\rho^2$</td>
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<td>0.19</td>
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<tr>
<td>BIC</td>
<td>4501.19</td>
<td>4458.27</td>
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<tr>
<td>Estimated Parameters</td>
<td>29</td>
<td>32</td>
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</table>
## Choice Correlation

<table>
<thead>
<tr>
<th>Nested Logit Model</th>
<th>Nesting Coefficient ($\lambda$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle – Shipment (VS)</td>
<td>0.62</td>
</tr>
<tr>
<td>Shipment – Vehicle (SV)</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Conclusion

➢ Applications in policy analysis

  • Demand for parking facilities, loading bays
  • Greenhouse gas emissions
  • E-commerce, same-day deliveries
Conclusion

- Significant correlation found in the choice of vehicle type and shipment size
- Both model structures are possible
- A latent class model with both model structures should be tested
More about this work!

• More details about models and results can be found in: