Integrating Axle Configuration, Truck Body Type, and Payload Data to Estimate Commodity Flows

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1. Introduction
2. Source data
3. Methodology
4. Results
   a) Configuration-body type
   b) Gross vehicle weights (GVWs)
   c) Payloads (illustrative)
5. Concluding remarks
1. Introduction: purpose

• To illustrate potential to utilize **axle configuration**, **truck body type**, and **payload** data to estimate industry-specific commodity flows

• Motivation:
  • Transportation planners make regional transportation infrastructure investments based on expected industry activity
  • Infrastructure design features should reflect expected truck traffic characteristics
  • Key Manitoba example: development of a trimodal inland port in Winnipeg (CentrePort Canada)
1. Introduction: background

- Typical freight demand modelling process (e.g., Freight Analysis Framework):
  - Tonnes by commodity
  - Mean payload for configuration-body type pair
  - Truck volume (by vehicle class), weight
1. Introduction: background

- Truck traffic monitoring programs could provide data that would enable prediction of commodity tonnage by industry.
1. Introduction: background

• Truck traffic monitoring programs could provide data that would enable prediction of commodity tonnage by industry

- Tonnes by commodity (by industry)
- Mean payload for configuration-body type pair
- Truck volume (by vehicle class), weight
2. Source data

- Manual roadside surveys and sample photo weigh-in-motion (WIM) data
  - Three fixed static weigh scale locations
  - One new piezo-quartz WIM site (with photo)
  - Sites on Manitoba’s National Highway System (divided highways)
  - 48 continuous hours at each location
  - Nearly 6500 truck observations
  - Similar historical data available

- Each observation records:
  - Vehicle class (compatible with 13-class scheme)
  - Axle configuration
  - Body type (e.g., van, tanker, hopper bottom)
  - Axle weight
2. Source data: survey locations
3. Methodology

1. Clean and aggregate sample data

2. Identify relationships between axle configuration and truck body type to select predominant configuration-body type pairs

3. Analyze GVW distributions to determine mean loads and loading patterns

4. Estimate mean payloads for predominant axle configuration-body type pairs
4. Results: configuration-body type

- Aggregated results show predominant configurations and body types
- Typical commodities and industries are inferred

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Body type</th>
<th>Typical commodities</th>
<th>Typical industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five-axle tractor semitrailer, 3-S2</td>
<td>Vans/reefers</td>
<td>• Palletized cargo</td>
<td>• Retail</td>
</tr>
<tr>
<td></td>
<td>(63%)</td>
<td>• Refrigerated goods</td>
<td>• Produce</td>
</tr>
<tr>
<td></td>
<td>Flat decks</td>
<td>• Equipment</td>
<td>• Construction</td>
</tr>
<tr>
<td></td>
<td>(16%)</td>
<td>• Building supplies</td>
<td>• Manufacturing</td>
</tr>
<tr>
<td></td>
<td>Hoppers</td>
<td>• Grain</td>
<td>• Agriculture</td>
</tr>
<tr>
<td></td>
<td>(6%)</td>
<td>• Granular fertilizer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tankers</td>
<td>• Petroleum products</td>
<td>• Petroleum</td>
</tr>
<tr>
<td></td>
<td>(4%)</td>
<td>• Chemicals</td>
<td>• Chemical</td>
</tr>
<tr>
<td></td>
<td>Dumps</td>
<td>• Aggregate</td>
<td>• Construction</td>
</tr>
<tr>
<td></td>
<td>(6%)</td>
<td>• Grain</td>
<td>• Agriculture</td>
</tr>
<tr>
<td></td>
<td>Containers</td>
<td>• Palletized cargo</td>
<td>• Retail</td>
</tr>
<tr>
<td></td>
<td>(2%)</td>
<td>• Freight of all kinds</td>
<td></td>
</tr>
</tbody>
</table>

Note: Percentages do not sum to 100% because “other” configurations and body types are excluded
4. Results: configuration-body type

- General findings by axle configuration:

  - 3-S2: Majority are vans/reefers
  - 3-S3: Range of body types (vans/reefers, flat decks, containers, hoppers)
  - 3-S2-4: Effectively always vans/reefers
  - 3-S3-S2: Effectively never vans/reefers
4. Results: configuration-body type

Predominant configuration-body type pairs (% of total observations)

<table>
<thead>
<tr>
<th></th>
<th>3-S2</th>
<th>3-S3</th>
<th>3-S2-4</th>
<th>3-S3-S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van / Reefer</td>
<td>43</td>
<td>7</td>
<td>8</td>
<td>~0</td>
</tr>
<tr>
<td>Flat Deck</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Hopper</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Tanker</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Dump</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Container</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes:
• Percentages do not sum to 100% because “other” configurations and body types are excluded
• Total observations, n = 6471
## 4. Results: GVWs

Mean GVW for predominant configuration-body type pairs (kg)

<table>
<thead>
<tr>
<th></th>
<th>3-S2</th>
<th>3-S3</th>
<th>3-S2-4</th>
<th>3-S3-S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van / Reefer</td>
<td>25,778</td>
<td>30,155</td>
<td>45,784</td>
<td>N/A</td>
</tr>
<tr>
<td>Flat Deck</td>
<td>25,454</td>
<td>27,895</td>
<td>N/A</td>
<td>46,759</td>
</tr>
<tr>
<td>Hopper</td>
<td>29,382</td>
<td>31,467</td>
<td>N/A</td>
<td>38,957</td>
</tr>
<tr>
<td>Tanker</td>
<td>23,767</td>
<td>28,764</td>
<td>N/A</td>
<td>45,734</td>
</tr>
<tr>
<td>Dump</td>
<td>29,310</td>
<td>33,755</td>
<td>N/A</td>
<td>44,569</td>
</tr>
<tr>
<td>Container</td>
<td>22,359</td>
<td>26,457</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: 1 kg = 2.2 lb
4. Results: GVWs

3-S2 Van GVW

Sample n = 2805
Mean = 25,778 kg
4. Results: GVWs

3-S3 Hopper GVW

Sample n = 83
Mean = 31,467 kg
4. Results: GVWs

Sample n : 511
Mean = 45,784 kg

3-S2-4 Van GVW
4. Results: GVWs

3-S3-S2 Hopper GVW

Sample n = 182
Mean = 46,759 kg
4. Results: payloads (illustrative)

3-S3 Hopper GVW

Sample n = 83
Mean = 31,467 kg

Mean tare weight ≈ 15 tonnes
31% of observations empty
4. Results: payloads (illustrative)

Notes:
• Assumes 15 tonnes tare (mean)
• Empty trucks (31%) removed from sample

Sample n = 57
Mean = 24,314 kg

3-S3 Hopper Payload
4. Results: payloads (illustrative)

Mean payload for predominant laden configuration-body type pairs (kg)

<table>
<thead>
<tr>
<th></th>
<th>3-S2</th>
<th>3-S3</th>
<th>3-S2-4</th>
<th>3-S3-S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van / Reefer</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
</tr>
<tr>
<td>Flat Deck</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>✓</td>
</tr>
<tr>
<td>Hopper</td>
<td>✓</td>
<td>24,314</td>
<td>✓</td>
<td>N/A</td>
</tr>
<tr>
<td>Tanker</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>✓</td>
</tr>
<tr>
<td>Dump</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>✓</td>
</tr>
<tr>
<td>Container</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: 1 kg = 2.2 lb
5. Concluding remarks

• Truck traffic monitoring programs provide a critical data for highway management decisions, but cannot be easily related to industry activity

• Opportunity to leverage truck traffic data
  • Body type can be linked to commodity/industry
  • Relationship between configuration and body type
  • Unique data set provides GVW and payload means and distributions for predominant axle configuration-body type pairs

• Data collection process is onerous, but new technologies available to automate this
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