INTERMODALISM IN URBAN LOGISTICS: AN ENVIRONMENTAL ASSESSMENT OF CARGO TRICYCLE USED FOR BEVERAGE DISTRIBUTION IN RIO DE JANEIRO CITY

Amanda Fernandes Ferreira
Professor S.K. Jason Chang

National Taiwan University

June, 2018
Brazil and Rio de Janeiro

• Brazilian population living in urban areas:
  – 85.8% (2015);
  – 90% (2035);
  – 96.7% (Rio de Janeiro State);

• Rio de Janeiro is one of the 31 world Megacities (12,200,000 inhabitants).

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- Problem
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Freight Transportation impact

Impacts of Freight Transportation in Urban Areas

- **Environment**
  - GHG and pollutants emission
  - Noise pollution
  - Vibrations

- **Infrastructure**
  - Pavement Life cycle

- **Energy**
  - Fuel consumption

- **Traffic**
  - Safety
  - Traffic Jam
  - Road capacity

- **Economic**
  - Operation cost
Freight vehicles access restrictions

- **Polygon 1 (north and west zone)**
  - Working days: 6am - 11am and 5pm - 9 pm.
  - Saturdays: 6am - 2 pm.

- **Polygon 2 (center and south zone)**
  - Working days: 6am – 9pm.
  - Saturdays: 6am - 2pm.

- **Brazil avenue**
  - Working days: 6am – 10am and 5pm - 9 pm.

- **Yellow line**
  - All days: 6am – 11am and 5pm - 9 pm.

- **Red line**
  - 24 hours per day.

Source: Rio de Janeiro City Hall website
Alternative operation

Operational scheme of truck route for direct delivery

Operational scheme tricycle + truck route
Alternative operation
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Environmental and economic performance

Traditional Truck-based delivery

Truck as a mobile depot + Pedal cargo tricycle (hypothetical)

Truck as a mobile depot + Motorized tricycle
# Environmental and economic performance

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load and unload time.</td>
<td>50 min</td>
<td>13 min</td>
<td>13 min</td>
</tr>
<tr>
<td>Average time between two clientes (truck) or between departure from and return to transshipment point (truck + tricycle).</td>
<td>11 min</td>
<td>49 min</td>
<td>49 min</td>
</tr>
<tr>
<td>Average distance between two clientes (truck) or between departure from and return to transshipment point (truck + tricycle).</td>
<td>2,21 km</td>
<td>3,80 km</td>
<td>3,80 km</td>
</tr>
<tr>
<td>Average speed between two clientes (truck) or between departure from and return to transshipment point (truck + tricycle).</td>
<td>12 km/h</td>
<td>4.65 km/h</td>
<td>4.65 km/h</td>
</tr>
<tr>
<td>Average number of stops per day.</td>
<td>9</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total time traveled (departure until return to DC).</td>
<td>11h 36 min</td>
<td>11h 8 min</td>
<td>11h 8 min</td>
</tr>
<tr>
<td>Total distance traveled</td>
<td>59.7 km</td>
<td>127 km</td>
<td>127 km</td>
</tr>
<tr>
<td>Workforce per vehicle</td>
<td>Driver + 2 helpers</td>
<td>Driver + 2 helpers + tricycle driver</td>
<td>Driver + 2 helpers + tricycle driver</td>
</tr>
</tbody>
</table>
Routes
# Emission Factors

<table>
<thead>
<tr>
<th>EMISSION FACTORS</th>
<th>CO2 (kg/km)</th>
<th>Atmospheric pollutants (g/km)</th>
<th>Fuel Consumption (km/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium truck</td>
<td>0.85</td>
<td>1.11</td>
<td>3.2 km/l</td>
</tr>
<tr>
<td></td>
<td>2.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2 km/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorcycle (after 2010)</td>
<td>0.11</td>
<td>0.73</td>
<td>19 km/l</td>
</tr>
<tr>
<td></td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0035</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19 km/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicycle or tricycle (electric or not)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: Inventário Nacional de Emissões Atmosféricas por Veículos Automotores Rodoviários, 2013
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Emission results

**% kg/day**

- CO2 = 20%
- CO = 19%
- NOx = 20%
- NMHC = 20%
- PM = 20%

**% g/day**

- CO2 = 16%
- CO = 49%
- NOx = 4%
- NMHC = 50%
- PM = 20%

**% kg/km**

- CO2 = 60%
- CO = 59%
- NOx = 58%
- NMHC = 60%
- PM = 60%

**% g/km**

- CO2 = 16%
- CO = 49%
- NOx = 1%
- NMHC = 50%
- PM = 21%
## Costs results

<table>
<thead>
<tr>
<th>Costs</th>
<th>Truck</th>
<th>Truck + motorized tricycle</th>
<th>Truck + pedal tricycle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed cost (vehicle)</strong></td>
<td>USD/month</td>
<td>USD/month</td>
<td>USD/month</td>
</tr>
<tr>
<td>USD/month</td>
<td>$411</td>
<td>Truck = $411</td>
<td>Truck = $411</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tricycle = $39</td>
<td>Tricycle = $17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total = $450</td>
<td>Total = $428</td>
</tr>
<tr>
<td><strong>Variable cost (fuel)</strong></td>
<td>USD/month</td>
<td>USD/month</td>
<td>USD/month</td>
</tr>
<tr>
<td>USD/month</td>
<td>$14/day</td>
<td>Truck = $11/day</td>
<td>Truck = $11/day</td>
</tr>
<tr>
<td></td>
<td>$420/month</td>
<td>Tricycle = $3/day</td>
<td>Tricycle = $0/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total = $14/day – $420/month</td>
<td>Total = $11/day – $330/month</td>
</tr>
<tr>
<td><strong>Total USD/month</strong></td>
<td>$831</td>
<td>$870</td>
<td>$758</td>
</tr>
</tbody>
</table>

- Maintenance costs;
- Governmental tax costs;
- Insurances cost;
- Fluctuations in fuel cost;
- Etc.
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Conclusions

• **60%↓** emission (kg/km) {truck};
• Service level and logistic operation unaffected;
• Significant **reduction** in environmental impact (all emission and both scenarios);
• **9%** to **13%↓** analyzed costs.
• High **potential** to reduce total cost of operation.
Thanks for listening!