Urban Freight Transport Policies in Rome: Lessons Learned and the Road Ahead

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Overview

✓ Introduction
✓ City Logistics Policies Framework
✓ Policy Assessment Methodology
✓ City Logistics Policies in Rome
✓ The surveys
✓ Modeling Framework to Assess City Logistics Scenarios
✓ Conclusions
Overview

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Municipality of Rome

Population density [inh./km²]

- Northern Italy
  - Inhabitants: 2,546,804
  - Employees: 1,098,172
  - Economic activities: 230,353

- Southern Italy

Main road network
Introduction

Municipality of Rome

*Retail employees respect to population*

Northern Italy

Southern Italy

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Urban Freight Transport Policies in Rome: Lessons Learned and the Road Ahead
Introduction

Municipality of Rome

Warehouse employees respect to population

- Northern Italy
- Southern Italy

Legend:
- 0.029 to 0.145 (24)
- 0.02 to 0.029 (18)
- 0.015 to 0.02 (15)
- 0.011 to 0.015 (18)
- 0 to 0.011 (24)
Municipality of Rome

Inner zone

Inner area (freight LTZ)

✓ 6 km²
✓ 51,413 inhabitants
✓ 130,000 employees
✓ 24,401 trade employees
Introduction

Municipality of Rome

Inner zone

The Colosseum
The Forums
Pantheon and Piazza Navona
The Trevi Fountain
Piazza di Spagna
The Capitoline Hill
The Colosseum
Mouth of Truth

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Urban Freight Transport Policies in Rome: Lessons Learned and the Road Ahead
Introduction

The freight distribution in the inner zone contributes:

- to congestion, air pollution, noise (environmental impacts)

- to have a combination of different types of vehicles on the road that increases the risk of accidents (social impacts)

- to raise logistic costs, and hence the price of products (economic impacts)
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City logistics policies framework

Strategies

✓ In order to assure an efficient urban freight distribution system, able to meet the requests of several involved stakeholders and to minimize the externalities, the city administration has been implementing some strategies:

- reduction of number of commercial vehicles and increasing of commercial speed (economic/financial sustainability),
- use of light and environmental-friendly vehicles (environmental sustainability),
- reduction of interferences with other components of city mobility (social sustainability).
## City logistics policies framework

<table>
<thead>
<tr>
<th>Policies/Measures</th>
<th>Strategies</th>
<th>Planning horizons</th>
<th>Receiver /Sender</th>
<th>Relevant impacts (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight and dimension constraints</td>
<td>Use of light vehicles</td>
<td>Tactical/Operative</td>
<td>X</td>
<td>Transp. costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Congestion</td>
</tr>
<tr>
<td>Time windows</td>
<td>Reduction of interference</td>
<td>Operative</td>
<td>X</td>
<td>Envir.</td>
</tr>
<tr>
<td>Emmision constraints</td>
<td>Use of environmental-friendly vehicles</td>
<td>Tactical/Operative</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Electronic Access Control</td>
<td>Reduction of number of vehicles</td>
<td>Tactical/Operative</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Area-pricing</td>
<td>Reduction of number of vehicles</td>
<td>Strategic/Tactical</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Incentives</td>
<td>Use of environmental-friendly vehicles</td>
<td>Strategic/Tactical</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nearby Delivery Area</td>
<td>Reduction of number of vehicles</td>
<td>Tactical/Operative</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Urban Distribution Center/Transit point</td>
<td>Use of light and environmental-friendly vehicles</td>
<td>Strategic</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

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✓ Conclusions
Policy assessment methodology

✓ The urban goods movements are the results of a set of choices made by:

- Inhabitants/customers
- Retailers
- Wholesalers, logistics operators and distributors
- City administrations

analysis and selection of implementable policies/measures has to consider such actors and find an optimal compromise between all interests of the involved actors
Policy assessment methodology

Current Scenario

Data collecting

Critical Issues

Consultation

New Current Scenario

New Scenario

Ex-ante Assessment

Models
Overview

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## City logistics policies in Rome

### Regulation over the last 10 years

<table>
<thead>
<tr>
<th>Measures/Polices</th>
<th>before 2001</th>
<th>2001 – 2011</th>
<th>after 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time windows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 3.5 t Access:</td>
<td>9.30am–11am</td>
<td>8pm–10am</td>
<td>8pm–7am</td>
</tr>
<tr>
<td>More than 3.5 t Access:</td>
<td>2.30pm – 4pm</td>
<td>2pm – 4pm</td>
<td>8am–4pm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exemptions for valuables, pharmaceuticals, newspapers, and vehicles carrying out maintenance activities</td>
<td></td>
<td></td>
<td>Exemptions for electric, LPG, CNG, hybrid vehicles less than 6.5 t complying the gauge of light goods vehicles (less than 3.5 t).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Emission constraints</strong></td>
<td>none</td>
<td>no access to Euro 0 and 1 freight vehicles</td>
<td>Max loading and unloading time: 30 minutes</td>
</tr>
<tr>
<td>Road-pricing</td>
<td>none</td>
<td>570 €/year discounts for Low Emission Vehicles (-20% CNG, LPG hybrid, -50% electric)</td>
<td>no access to Euro 0, 1, 2 (from 2012), 3 (from 2013) freight vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Depends on vehicle emission standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Road-pricing</strong></td>
<td>none</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electronic Access Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## City logistics policies in Rome

### Regulation before 2001

<table>
<thead>
<tr>
<th>Measures/ Policies</th>
<th>before 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Less than 3.5 t</strong></td>
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</tr>
<tr>
<td>Time windows</td>
<td></td>
</tr>
<tr>
<td>Access:</td>
<td>Access:</td>
</tr>
<tr>
<td>• 9.30am–11am</td>
<td>Specific path and time permissions</td>
</tr>
<tr>
<td>• 2.30pm–4pm</td>
<td></td>
</tr>
<tr>
<td>Exemptions for valuables, pharmaceuticals, newspapers, and vehicles carrying out maintenance activities</td>
<td></td>
</tr>
<tr>
<td>Emission constraints</td>
<td>none</td>
</tr>
<tr>
<td>Road-pricing</td>
<td>none</td>
</tr>
</tbody>
</table>

Due to the high number of exemptions and the low enforcement, this regulation had **little effects** in terms of reducing freight traffic in the inner area and of improving its environmental sustainability.

In 1999, the municipality carried out some surveys aiming at:
- identifying the problems of freight transport
- supporting the decisions on the actions to be implemented
Main 1999 survey results

- presence of *through freight* traffic representing the 34% of all freight trips
- the high share of *transport in own account* (54%) and of commercial vehicles *more than 1.5 tons* (74%)
- *problems of loading and unloading*, especially because of *insufficient parking space*
  (34% of retailers evidenced this problem, and only the 5% of interviewed truck drivers have declared to use the legal space for loading and unloading operations)
City logistics policies in Rome

Regulation between 2001 and 2011

In 2001, a new regulation for freight traffic with restrictions on access to and parking in the inner area was in place. In addition, for a large portion of the inner area an electronic system of access control has been implemented for both passenger and freight vehicles.

Main objectives:

- Increasing of 3P
- to reduce the share of most pollutant vehicles
- to reduce the share of heavy vehicles

<table>
<thead>
<tr>
<th>Measures/ Policies</th>
<th>2001 – 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than</td>
</tr>
<tr>
<td></td>
<td>3.5 t</td>
</tr>
<tr>
<td>Time windows</td>
<td>Access:</td>
</tr>
<tr>
<td></td>
<td>• 8pm–10am</td>
</tr>
<tr>
<td></td>
<td>• 2pm – 4pm</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exemptions for third account vehicles, and specific freight types

Emission constraints

- no access to Euro 0 and 1 freight vehicles

Electronic Access Control

- Road-pricing 570 €/year
- discounts for Low Emission Vehicles (-20% CNG, LPG hybrid, -50% electric)
Main 2008 survey results

- to create incentives for 3P:
  Time windows and charging scheme allowed to reduce the transport in own account from 54% to 21%

- to reduce the share of most pollutant vehicles:
  New regulation pushed to use more environment-friendly vehicles (83% were at least Euro 3 or 4)

- to reduce the share of heavy vehicles:
  New regulation pushed to use light vehicles (from 44% to 65%)
City logistics policies in Rome

Regulation between 2001 and 2011

✓ Persisting problems from 2008 surveys

- the frequency of restocking has increased and there are more retailers receiving goods one or more times a day
- the number of freight vehicles in the area has increased from 1999 to 2008 by about 24%
- pollutant level in the inner area is still too high and often the standard environmental limits are exceeded
- the share of retailer considering very important problems related to the space for loading and unloading operations has increased (69%)
City logistics policies in Rome

Regulation after 2011

<table>
<thead>
<tr>
<th>Measures/ Policies</th>
<th>after 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Less than 3.5 t</strong></td>
<td><strong>More than 3.5 t</strong></td>
</tr>
<tr>
<td><strong>Time windows</strong></td>
<td></td>
</tr>
<tr>
<td>Access (Euro 2 and 3):</td>
<td>Access:</td>
</tr>
<tr>
<td>• 8pm–7am</td>
<td>• 8pm–7am</td>
</tr>
<tr>
<td>• 10am – 4pm</td>
<td>and subject to specific</td>
</tr>
<tr>
<td>Access (Euro 4, 5 and 6):</td>
<td>path and time</td>
</tr>
<tr>
<td>• 8pm–5.30pm</td>
<td>permissions</td>
</tr>
<tr>
<td><strong>Exemptions for electric, LPG, CNG, hybrid</strong></td>
<td></td>
</tr>
<tr>
<td><strong>vehicles less than 6.5 t complying the gauge</strong></td>
<td></td>
</tr>
<tr>
<td><strong>of light goods vehicles (less than 3.5 t)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Electronic Access Control</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Max loading and unloading time:</strong></td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td></td>
</tr>
<tr>
<td><strong>Emission constraints</strong></td>
<td></td>
</tr>
<tr>
<td>no access to Euro 0, 1, 2 (from 2012), 3</td>
<td></td>
</tr>
<tr>
<td>(from 2013) freight vehicles</td>
<td></td>
</tr>
<tr>
<td><strong>Road-pricing</strong></td>
<td></td>
</tr>
<tr>
<td>Depends on vehicle emission standards</td>
<td></td>
</tr>
</tbody>
</table>

In 2008, the evaluations highlighted that good but not too satisfactory results have been obtained.

New actions have been planned from 2012 for reaching higher levels of sustainability.
City logistics policies in Rome

*Regulation after 2011*

**Phase I** (implemented from November 2011)

New access limits for commercial vehicles (both vehicles for freight distribution and services) have been introduced:

- no access to vehicles do not comply the Euro 2 standards;

- environmental-friendly vehicles (i.e. CNG, LPG, hybrid and electric) have a reduced charge for accessing within study area.
City logistics policies in Rome

Regulation after 2011

✓ Fase I design and preliminary *ex-ante* assessment

- to adjust the fees in order to obtain revenues which could support the new integrative measures (e.g. control of loading and unloading zones)

- good results can be obtained in terms of pollutant reductions, e.g. the matter particulate could be reduced of 6% in 2012, and 33% from 2013
City logistics policies in Rome

Regulation after 2011

Phase II (to be implemented in 2013)

✓ from 2013 no access to vehicles do not comply the Euro 3 standards;

✓ incentives to buy new environmental-friendly vehicles,

✓ enforcing for verifying the correct use of loading and unloading zones.
City logistics policies in Rome

Regulation after 2011

Measures to be verified

- Ban access to all vehicles (both private and commercial)
- Implementation of Nearby Delivery Area for commercial activities of the inner area
City logistics policies in Rome

Regulation after 2011: Nearby Delivery Area

Measures to be verified
City logistics policies in Rome

Regulation after 2011: Public Urban Distribution Centres for improve the two-tier distribution system

Measures to be verified

Northern Italy

Southern Italy

MainRoad Network

Public Urban Distribution Centres
Overview

- Introduction
- City Logistics Policies Framework
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- The surveys
  - Modeling Framework to Assess City Logistics Scenarios
- Conclusions
The surveys

Structure

✓ traffic counts of commercial and private vehicles

✓ telephone interviews to retailers

✓ interviews to truck drivers

<table>
<thead>
<tr>
<th>Traffic counts</th>
<th>Telephone interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Retailers</td>
</tr>
<tr>
<td>1999 28 sections</td>
<td>250 (12%)</td>
</tr>
<tr>
<td>2008</td>
<td>575 (38%)</td>
</tr>
</tbody>
</table>

(-) response rate
The surveys

Traffic counts

<table>
<thead>
<tr>
<th>7am – 6pm</th>
<th>Cars</th>
<th>Commercial vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>195,190</td>
<td>25,556</td>
</tr>
<tr>
<td>2008</td>
<td>216,922</td>
<td>25,382</td>
</tr>
</tbody>
</table>

Daily incidence of freight vehicles:
- ✔ 12% (1999)
- ✔ 9% (2008)
Traffic counts

Considering that in 2008 through freight traffic can be assumed zero, the freight traffic attracted by the zone has grown of about 24%.

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>2008</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross laden weight less than 1.5 tons</td>
<td>57%</td>
<td>26%</td>
</tr>
<tr>
<td>Gross laden weight within 1.5 and 3.5 tons</td>
<td>33%</td>
<td>50%</td>
</tr>
<tr>
<td>Gross laden weight within 3.5 and 8.5 tons</td>
<td>10%</td>
<td>22%</td>
</tr>
<tr>
<td>Other vehicles</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
### Retailer interviews

#### Sale surface

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100 m²</td>
<td>68%</td>
<td>82%</td>
</tr>
<tr>
<td>Between 100 and 200 m²</td>
<td>27%</td>
<td>15%</td>
</tr>
<tr>
<td>More than 200 m²</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

#### Average number of employees

<table>
<thead>
<tr>
<th>Activity type</th>
<th>2008</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retailers and public concerns</td>
<td>2.98</td>
<td>2.40</td>
</tr>
<tr>
<td>Craftsmen</td>
<td>2.37</td>
<td>2.70</td>
</tr>
</tbody>
</table>
Retailer interviews

Transport in own account

✓ In 1999, 54% of businesses transported in own account, in 2008 only 21%.

2008

- Cars and SUVs: 71%
- Vehicles with gross laden less than 1.5 ton: 7%
- Vehicles with gross laden between 1.5 and 3.5 ton: 22%

1999

- Cars and SUVs: 61%
- Vehicles with gross laden less than 1.5 ton: 9%
- Vehicles with gross laden between 1.5 and 3.5 ton: 30%
# Truck driver interviews

<table>
<thead>
<tr>
<th>Fuel</th>
<th>2008 Less than 1.5 t</th>
<th>2008 More than 1.5 t</th>
<th>2008 Total</th>
<th>1999 Less than 1.5 t</th>
<th>1999 More than 1.5 t</th>
<th>1999 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>8%</td>
<td>1%</td>
<td>8%</td>
<td>10%</td>
<td>3%</td>
<td>13%</td>
</tr>
<tr>
<td>Diesel</td>
<td>56%</td>
<td>34%</td>
<td>90%</td>
<td>33%</td>
<td>53%</td>
<td>86%</td>
</tr>
<tr>
<td>LPG</td>
<td>1%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>CNG</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>65%</td>
<td>35%</td>
<td>100%</td>
<td>44%</td>
<td>56%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Truck owners

- **61% (1999)**
- **39% (2008)**
Truck driver interviews

Delivery frequency
The surveys

**Truck driver interviews**

*Trip origin and destination*

**Trip origin**

- **2008**
  - 72% Establishment
  - 23% Shop and public concern
  - 5% Warehouse

- **1999**
  - 75% Establishment
  - 9% Shop and public concern
  - 16% Warehouse

**Trip destination**

- **2008**
  - 96% Establishment
  - 3% Shop and public concern
  - 1% Store

- **1999**
  - 92% Establishment
  - 6% Shop and public concern
  - 2% Store
## Truck driver interviews
### Delivery time and number of deliveries

<table>
<thead>
<tr>
<th>Freight type</th>
<th>Delivery time [minutes]</th>
<th>Number of deliveries</th>
<th>Delivery time [minutes]</th>
<th>Number of deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Books and musical products</td>
<td>22</td>
<td>2.2</td>
<td>27</td>
<td>1.9</td>
</tr>
<tr>
<td>Building materials</td>
<td>32</td>
<td>1.8</td>
<td>37</td>
<td>1.2</td>
</tr>
<tr>
<td>Clothing</td>
<td>24</td>
<td>2.0</td>
<td>38</td>
<td>1.5</td>
</tr>
<tr>
<td>Flower</td>
<td>24</td>
<td>1.8</td>
<td>28</td>
<td>1.1</td>
</tr>
<tr>
<td>Foodstuffs</td>
<td>28</td>
<td>2.6</td>
<td>22</td>
<td>2.1</td>
</tr>
<tr>
<td>Home accessories</td>
<td>40</td>
<td>1.8</td>
<td>45</td>
<td>1.2</td>
</tr>
<tr>
<td>Household or electrical appliance</td>
<td>23</td>
<td>2.2</td>
<td>33</td>
<td>1.3</td>
</tr>
<tr>
<td>Hygiene products</td>
<td>21</td>
<td>1.8</td>
<td>23</td>
<td>1.6</td>
</tr>
<tr>
<td>Laundry</td>
<td>16</td>
<td>2.5</td>
<td>21</td>
<td>2.1</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>13</td>
<td>2.1</td>
<td>23</td>
<td>1.9</td>
</tr>
<tr>
<td>Stationery</td>
<td>25</td>
<td>2.0</td>
<td>23</td>
<td>1.5</td>
</tr>
<tr>
<td>Other goods</td>
<td>21</td>
<td>2.6</td>
<td>29</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>24</strong></td>
<td><strong>2.1</strong></td>
<td><strong>29</strong></td>
<td><strong>1.6</strong></td>
</tr>
</tbody>
</table>
Truck driver interview

Quantity flows (2008)

<table>
<thead>
<tr>
<th></th>
<th>Emitted [tons/day]</th>
<th>Attracted [tons/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Materials</td>
<td>-</td>
<td>467.7</td>
</tr>
<tr>
<td>Clothing</td>
<td>38.2</td>
<td>1,075.0</td>
</tr>
<tr>
<td>Foodstuffs</td>
<td>34.4</td>
<td>5,234.2</td>
</tr>
<tr>
<td>Home accessories</td>
<td>88.3</td>
<td>2,863.8</td>
</tr>
<tr>
<td>Household and personal hygiene</td>
<td>0.1</td>
<td>207.4</td>
</tr>
<tr>
<td>Stationery</td>
<td>31.0</td>
<td>2,475.9</td>
</tr>
<tr>
<td>Other goods</td>
<td>3.2</td>
<td>2,175.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>195.2</strong></td>
<td><strong>14,499.2</strong></td>
</tr>
</tbody>
</table>

✓ 82% of freight quantity is destined to satisfy end-consumer demand
The surveys

Truck driver

Distribution process (distributive logistics)

Rome (2008)

Producer

Distribution Center

Wholesaler

End-Consumer (final, intermediate)

Retailer/Public concern

Large-scale retail trade

Percentage respect to the freight outcoming from node

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Overview

✓ Introduction
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✓ Policy Assessment Methodology
✓ City Logistics Policies in Rome
✓ The surveys
✓ Modeling Framework to Assess City Logistics Scenarios
✓ Conclusions
### Choice dimensions, decision-makers and measures/policies

<table>
<thead>
<tr>
<th>Choice dimension</th>
<th>Demand</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distribution centre location?</td>
<td>Shop location and dimension?</td>
</tr>
<tr>
<td><strong>Decision-maker</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retailer</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Wholesaler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrier</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Measures/Policies**

- Urban Distribution Centre/transit point: x
- Time windows: x
- Weight constraints: x
- Road/parking pricing: x
- Incentives: x
- Specific permits: x
- ITS: x

---

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Modeling framework to assess city logistics scenarios

Main requirements

✓ To point out the decision-makers’ choices

✓ To take into account the effects on choices due to measures/policies implementations
Modeling framework to assess city logistics scenarios

**Structure**

- **Quantity** allows to capture the mechanisms underlying the freight demand generation

- **Delivery** allows to follow the decisional and logistic process of restocking

- **Vehicle** Input for assignment and performance models

```
Attraction
↓
Attracted quantities
↓
Acquisition
↓
Transport service
↓
quantity O-D matrices
↓
Shipment size
↓
Delivery time
↓
Departure time

Vehicle type
↓
Delivery location
↓
vehicle O-D matrices
```

**Model**

**Data**
Quantity model sub-system

\[ Q_{od} \left[ r \right] = Q_{d} \cdot p[o / d] \cdot p[r / od] \]

- \( Q_{od} \left[ r \right] \) is the average quantity flow of freight attracted by zone \( d \) and coming from zone \( o \) with transport service type \( r \);
- \( Q_{d} \) is the average quantity of freight attracted by zone \( d \) (attraction model);
- \( p[o / d] \) is the probability that freight attracted by zone \( d \) comes from zone \( o \) (e.g. production place/firm, distribution centre, warehouse, etc. - acquisition model);
- \( p[r / od] \) is the probability to be restocked by transport service type \( r \) (transport service type model).

For simplicity of notation, the class index \( s \) (freight type) and \( h \) (time period) have been taken as understood unless otherwise stated.
Revealed vs estimated quantities

Attracted Quantity

Quantity O-D flows
(Foodstuffs)

Quantity O-D flows
(Other goods)
Transport service type model

\[ p[r/od] \]

\( p[r/od] \) is the probability to be restocked by transport service \( r \)
Delivery model sub-system

\[ ND_{od} [\tau, r] = \frac{Q_{od} [r]}{q[r]} \cdot p[\tau / d] \]

✓ \( ND_{od} [\tau, r] \) is the number of deliveries carried out by service type \( r \) on od pair in time slice \( \tau \);
✓ \( Q_{od} [r] \) is the average freight quantity flow on od pair by service type \( r \);
✓ \( q[r] \) is the average freight quantity delivered with service type \( r \) (shipment size model).
✓ \( p[\tau / d] \) is the probability of having deliveries in time slice \( \tau \) (delivery time model)

For simplicity of notation, the class index \( s \) (freight type) and \( h \) (time period) have been taken as understood unless otherwise stated.
Revealed vs estimated deliveries

Attracted delivery flows
(Foodstuffs)

Attracted delivery flows
(Other goods)
Vehicle model sub-system

Average freight vehicle flow, $VC$, transporting freight type $s$ between the zone $o$ and the zone $d$ in time period $h$ characterized by:

- service type ($r$)
- time slice ($\tau$)
- departure time ($t$)
- number of stops ($n$)
- vehicle type ($v$)

$$VC_{od}^{sh}[vnt\tau r]$$

For simplicity of notation, the class index $s$ (freight type) and $h$ (time period) will be taken as understood unless otherwise stated ⇒ $VC_{od}[vnt\tau r]$
## Vehicle O-D Problem definition

### DELIVERIES

<table>
<thead>
<tr>
<th>O-D</th>
<th>o</th>
<th>d₁</th>
<th>d₂</th>
<th>d₃</th>
<th>d₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>o</td>
<td>nd₁</td>
<td>nd₂</td>
<td>nd₃</td>
<td>nd₄</td>
<td></td>
</tr>
<tr>
<td>d₁</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₄</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FREIGHT VEHICLES

<table>
<thead>
<tr>
<th>O-D</th>
<th>o</th>
<th>d₁</th>
<th>d₂</th>
<th>d₃</th>
<th>d₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>o</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₁</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₂</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₃</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d₄</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

- Restocker jointly chooses the **number** and the **location** of deliveries for each restocking tour
- Each restocker defines his tours trying to **reduce his costs** (e.g. using routing algorithm)
- The O-D matrices are the **sum** of single restocker **behaviours**
Vehicle sub-system structure

1. Delivery O-D matrices

2. Number of tours departing from a given zone $o$ (i.e., number of vehicles)

3. Definition of tours (i.e., sequence of stop locations per tour)

4. Vehicle O-D matrices

Mathematical expressions:

$$ND_{od} [\tau r]$$

$$T_o [vnt \tau r] = T_o [\tau r] \cdot p[t / \tau r] \cdot p[n / t \tau r] \cdot p[v / nt \tau r]$$

$$p\left[ d_j^{k+1} / d_i^k; vnt \tau r \right]$$

$$VC_{d_i d_j} \left[ vnt \tau r \right]$$
Delivery tour departure time

\[ p[t / \tau_{ro}] \]
Trip chain order distribution

\[ p[ n / \tau \rho ] \]

### All transport service types

- **Stops per tour**

### Retailer in own account

- **Stops per tour**

### Wholesaler in own account

- **Stops per tour**

### Carrier

- **Stops per tour**
Vehicle type

$p[v / nt\tau ro]$  

- **Light Goods Vehicles (less than 1.5 t)**: 35%
- **Medium Goods Vehicles (1.5 - 3.5 t)**: 65%

✓ Average transported quantity:
  - LGV (< 1.5 t): 800 kg
  - MGV (1.5 – 3.5 t): 1,716 kg

✓ Average shipment size
  - LGV (< 1.5 t): 185 kg
    - Retailer in own account: 183 kg
    - Wholesaler in own account: 214 kg
    - Carrier: 154 kg
  - MGV (1.5 – 3.5 t): 382 kg
    - Retailer in own account: 414 kg
    - Wholesaler in own account: 406 kg
    - Carrier: 336 kg
Next delivery location

\[ p\left[ \frac{d_{j}^{k+1}}{d_{i}^{k}} \right] \]

- The next stops within a tour is averagely close: 2.5 km (less than 6 minutes)

- The average ratio between the distance to be covered to reach the next delivery location and the current covered distance is 0.77

- 10% of next stops is within the same zone

- More stops/deliveries for foodstuffs

- The probability of a zone increases with its attraction capacity and closeness
It allows to take into account the influence of, e.g.:

- socio-economic characteristics of a traffic zone on attracted freight traffic;
- localization of freight centers (e.g. distribution centers, warehouses) on generated freight traffic for each zone;
- characteristics of shops with related depots and shipment size on the choice of service type (retailer in own account, wholesaler in own account, carrier) and vehicle type;
- type of freight, accessibility of origin and destination zones, type of vehicle, shipment size and capacity of attraction zone on the pattern of restocking tours.
Modeling framework to assess city logistics scenarios

Features

✓ It is able to evaluate the impacts of city logistics measures/policies that aim to, e.g.:

- increase the shipment size, with a variation of number of deliveries, pattern of restocking tour and vehicle type;
- reduce the passive accessibility (i.e. time windows and/or area-pricing, that push to restocking tour with more deliveries);
- try to concentrate retail activities (i.e. less vehicle-km and short tours);
- limit the dimensions of vehicles (with increasing of number of deliveries).
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Conclusions

✓ The 2001 implemented measures (mainly access restrictions and charging scheme with electronic access control) have caused some important changes in freight transport patterns within the inner area of Rome, e.g.:

➤ reduction of own account

➤ increasing of light and less pollutant vehicles
Conclusions

The 2008 survey shows that some critical aspects of urban freight transport still persist:

- the frequency of restocking with a higher number of retailers receiving goods one or more times a day is increased
- the absolute number of freight vehicles accessing the inner area is increased
- the goods movements are still concentrated in the morning hours
- the lack of loading and unloading zones
Even though other measures have been implemented after 2011, further measures to improve the efficiency of goods distribution process are in progress:

- Two-tier distribution system
- Nearby Delivery Area within the inner area
- Four Peripheral Public Distribution Centers
Conclusions

✓ Further analysis in order to improve the calibrated models for the ex-ante assessment

✓ Extension of data analysis and modeling in order to consider land-use/transport interaction:

➢ Shopping mobility (e.g. user’s behavior)

➢ Retailing, public concern and large-scale retail trade locations
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