



A Demand Model for Freight Movements in City Logistics Applications

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This research has been performed in collaboration with the Assessorato Mobilità e Trasporti of the Region of Emilia-Romagna



CityGoods project overview

- Which field is focused ?
 - urban goods traffic, trips for shopping (to be done)
- Which are the objectives for modelling
 - diagnosis, allocation of the flows of vehicles, help for the decision-makers understanding the urban logistics mechanisms
- The design of the model
 - (see presentation)



CityGoods project overview

- The type of data used to calibrate the model
 - registers or surveys towards hauliers, shippers, establishments, drivers
- Which are (as far as possible precisely) the mathematical relationships
 - (see presentation)
- The model is currently a prototype, a software package is under development (first release: october-november 2006)



CityGoods project overview

- Does it need a large competence to be used?
 - Familiarity with classical people transportation models
- Is it in progress or achieved? In progress
- Who is using the model and to obtain which results?
 - Emilia-Romagna region as a followup activity of Interreg III/b CityPorts Project and to study regional freight mobility



Talk outline

- The CityPorts Project and the CityPorts approach to urban logistics
- Emilia-Romagna's towns logistic surveys
- Towards a unified modeling framework for Urban Logistics (CityGoods)
 - Step 1: a demand generation model
 - Overview and preliminary results
- Conclusions and further study directions

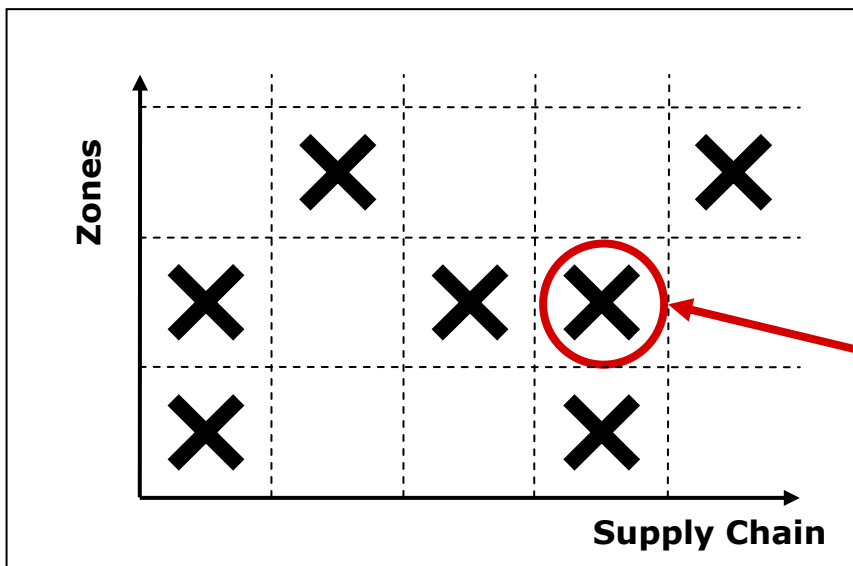


The CityPorts Project

- CityPorts (EU INTERREG III/B 2003-05), coordinated by Regione Emilia-Romagna, proposes a general methodological framework for the design and evaluation of City Logistics Actions (support initiatives):
 - Infrastructures
 - Policies and regulations ...
- The approach relies on the analysis of the different supply chains and their impact on the different zones of the urban area

The Zones-Supply Chains Grid

- Logistic characterization of towns is based on the construction of the Zones-Supply Chains (ZS) Grid as a “reading guide” of the town in Logistic terms



measure of criticality:

- qualitative (■, ■, ■)
- quantitative (n. of opns)



Logistic Actions Evaluation

- Action mapping into a ZS Grid gives the basis for Action effect evaluation (and possible re-design)
- Need of a quantitative ZS Grid
- ➔ Need of a Supply-Chain-based Demand Generation Model
 - to define the ZS Grid
 - to be used within classical transp. models



CityGoods Modeling framework

- Unified modeling approach:
 - Description of City Logistics phenomena
 - For a specific town and for a regional territory
 - Definition of qualitative and quantitative indicators of City Logistics in ER towns
 - That may be used for evaluation and planning purposes
 - CityPorts methodology and Classical transportation analysis
- Main element is a specifically designed Logistic Demand Generation Model



ER City logistic surveys

- In the years 2003-05 Emilia-Romagna performed an extensive survey of City Logistics phenomenon for all ER towns
 - CityPorts, Merope, Regional programmes ...
- Huge and fine-grained data source
 - Quite homogeneous (CityPorts survey model)
 - 3 main surveys: Demand Generation, Attraction and flows/operations
- A unique modeling opportunity !



Demand Generation Models

- General survey: Russo & Comi (2004)
 - *gravitational, 4 Phases* (Hutchinson 1974, Odgen 1992, List & Turnquist 1994, Taylor 1997, He & Crainic 1998, Gorys & Hausmanis 1999 ...)
 - *input-output* (Harris & Liu, 1998)
 - *spatial price equilibrium* (Oppenheim 1994, Nagurney, 2002)
- the first is more suited to a urban scale



Demand Generation Models

- *Some problems:*
 - Generation: intrinsic approximation introduced by aggregating many economic activities into few categories
 - a given economic activity generates movements belonging to different Supply Chains
 - Distribution: a vehicle performs many deliveries/pickups in a tour



Other experiences

- FRETURB (L.E.T., Lyon, Fr): general model for the evaluation of the impact of Logistic Actions
 - Based on 3 detailed surveys on French towns (Marseilles, Bordeaux and Dijon)
 - Regression-based model
 - Software tool distributed by French Ministry of Transport to all French Municipality
- VISEVA (Friedrich et al 2003), Good Trips (Boerkamps, 1999)



Demand Generation Model

- Objective: estimate the yearly number of operations generated by each SC - Zone
- Starting Points:
 - ER surveys on Demand Generators:
 - Small samples wrt Universe (BO: 250-500 of 35131)
 - Rich of logistic information (opns generated per SC, time distribution, type of vehicles ...)
 - Universe
 - Municipality, CCIAA Data ... ASIA ER Database
 - No Supply-chain related classification (only ATECO/NACE economic classification, NAICS in USA ...)

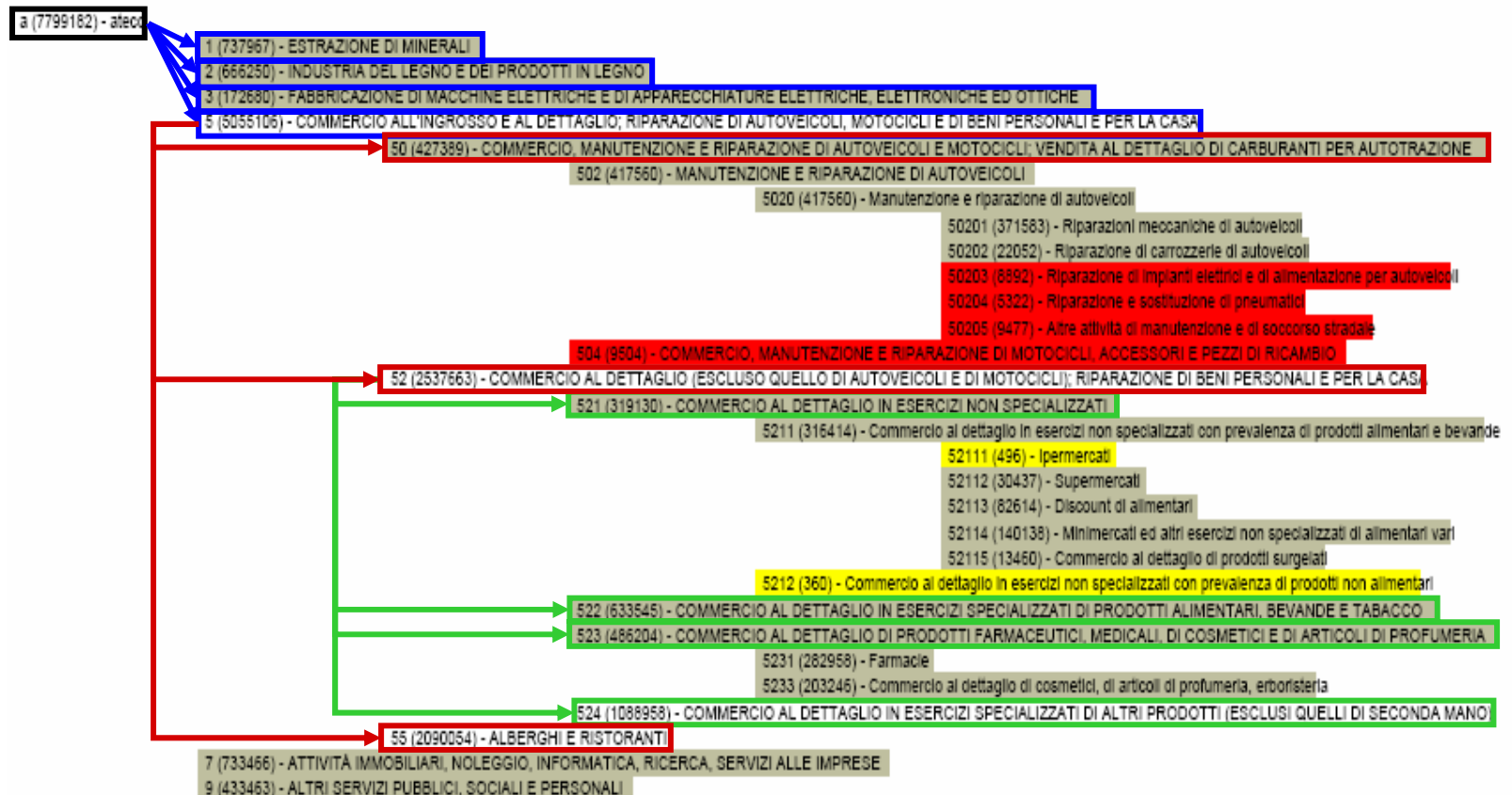


Demand Generation Model (2)

- Overall approach:
 - No “a-priori” aggregation of activities into categories (SC)
 - Characterize demand generation directly using the ATECO/NACE classification of the generators (operations per NACE code)
 - Hundreds of codes and small samples! → Exploit the hierarchic structure of the classification within the model
 - Use survey data to calibrate the model and define the specific SC generation models
- Result:
 - Very fine-grained information wrt to classical index-by-category approaches

NACE classification tree

■ 5 Digits code with hierarchic structure



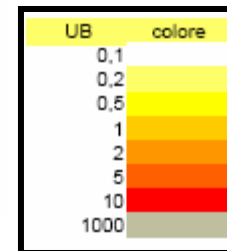
NACE classification tree (2)

- Mapping of the Universe into the NACE tree gives immediate indicators of town structure (overall and spatial=per Zone)

a (35131) - ateco

- 0 (137) - AGRICOLTURA, CACCIA E SILVICOLTURA
- 1 (1196) - ESTRAZIONE DI MINERALI
- 2 (1375) - INDUSTRIA DEL LEGNO E DEI PRODOTTI IN LEGNO
- 3 (1024) - FABBRICAZIONE DI MACCHINE ELETTRICHE E DI APPARECCHIATURE ELETTRICHE, ELETTRONICHE ED OTTICHE
- 4 (3332) - PRODUZIONE E DISTRIBUZIONE DI ENERGIA ELETTRICA, GAS E ACQUA
- 5 (14074) - COMMERCIO ALL'INGROSSO E AL DETTAGLIO; RIPARAZIONE DI AUTOVEICOLI, MOTOCICLI E DI BENI PERSONALI E PER LA CASA
 - 50 (1001) - COMMERCIO, MANUTENZIONE E RIPARAZIONE DI AUTOVEICOLI E MOTOCICLI; VENDITA AL DETTAGLIO DI CARBURANTI PER AUT
 - 51 (4567) - COMMERCIO ALL'INGROSSO E INTERMEDIARI DEL COMMERCIO, AUTOVEICOLI E MOTOCICLI ESCLUSI
 - 52 (6254) - COMMERCIO AL DETTAGLIO (ESCLUSO QUELLO DI AUTOVEICOLI E DI MOTOCICLI); RIPARAZIONE DI BENI PERSONALI E PER LA CASA
 - 521 (378) - COMMERCIO AL DETTAGLIO IN ESERCIZI NON SPECIALIZZATI
 - 522 (892) - COMMERCIO AL DETTAGLIO IN ESERCIZI SPECIALIZZATI DI PRODOTTI ALIMENTARI, BEVANDE E TABACCO
 - 523 (362) - COMMERCIO AL DETTAGLIO DI PRODOTTI FARMACEUTICI, MEDICALI, DI COSMETICI E DI ARTICOLI DI PROFUMERIA
 - 524 (3514) - COMMERCIO AL DETTAGLIO IN ESERCIZI SPECIALIZZATI DI ALTRI PRODOTTI (ESCLUSI QUELLI DI SECONDA MANO)
 - 525 (48) - COMMERCIO AL DETTAGLIO DI ARTICOLI DI SECONDA MANO
 - 526 (759) - COMMERCIO AL DETTAGLIO AL DI FUORI DEI NEGOZI
 - 527 (291) - RIPARAZIONE DI BENI DI CONSUMO PERSONALI E PER LA CASA
- 65 (2252) - ALBERGHI E RISTORANTI
- 6 (3596) - TRASPORTI, MAGAZZINAGGIO E COMUNICAZIONI
- 7 (7815) - ATTIVITÀ IMMOBILIARI, NOLEGGIO, INFORMATICA, RICERCA, SERVIZI ALLE IMPRESE
 - 70 (2771) - ATTIVITÀ IMMOBILIARI
 - 71 (224) - NOLEGGIO DI MACCHINARI E ATTREZZATURE SENZA OPERATORE E DI BENI PER USO PERSONALE E DOMESTICO
 - 72 (1172) - INFORMATICA E ATTIVITÀ CONNESSE
 - 73 (70) - RICERCA E SVILUPPO
 - 74 (3578) - ATTIVITÀ DI SERVIZI ALLE IMPRESE
 - 741 (1065) - ATTIVITÀ LEGALI, CONTABILITÀ, CONSULENZA FISCALE E SOCIETARIA; STUDI DI MERCATO E SONDAGGI DI OPINIONE;
 - 742 (419) - ATTIVITÀ DEGLI STUDI DI ARCHITETTURA, INGEGNERIA ED ALTRI STUDI TECNICI
 - 743 (31) - COLLAUDI ED ANALISI TECNICHE
 - 744 (442) - PUBBLICITÀ
 - 745 (90) - SERVIZI DI RICERCA, SELEZIONE E FORNITURA DI PERSONALE
 - 746 (30) - SERVIZI DI INVESTIGAZIONE E VIGILANZA
 - 747 (423) - SERVIZI DI PULIZIA E DISINFESTAZIONE
 - 748 (1052) - ALTRE ATTIVITÀ DI SERVIZI ALLE IMPRESE
- 8 (585) - ISTRUZIONE
- 9 (1994) - ALTRI SERVIZI PUBBLICI, SOCIALI E PERSONALI

Bologna
Universe





NACE-Based Model

■ Main assumption

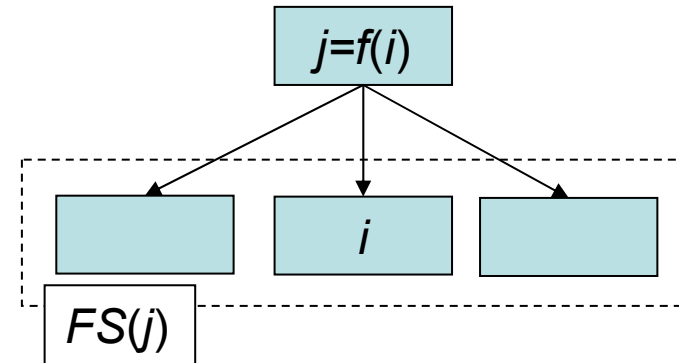
- The n. of operations generated by a specific NACE code (e.g. 502 Vehicle Maintenance) should take into account:
 - Those generated by the “descendant” codes (5020, 5021, ... 50201, ..., 50205)
 - Those generated by “parent” classes (50, 5)
- Measured by two contributes:
 - the relative weight (n. of elements in the Universe) of the subtree rooted at the code
 - relative weight of the path to the tree root

Model Formulation

NACE tree structure:

- N set of NACE codes
- $f(i)$ father of code $i \in N$
- $FS(i) = \{j \in N: f(j) = i\}$ $i \in N$
- r root tree

- M_i^s number of yearly operations of the supply chain $s \in S$ generated by code $i \in N$ (model output)
- m_i^s number of yearly operations associated to the link entering $i \in N$ (parameters to be determined by calibration)





Model Formulation (2)

- $M_i^s = W_i^s + H_i^s \quad i \in N$
- W_i^s contrib. to M_i of the subtree with root i
- H_i^s contrib. to M_i of the path from i to r (for leaves $M_i^s = H_i^s$)
- $H_i^s = m_i^s + H_{f(i)}^s \quad i \in N$
(computed in topological order)
- $W_i^s = \sum_{j \in FS(i)} \beta_j \cdot (W_j^s + m_j^s) \quad i \in N$
(computed in reverse topological order)
- β_j probability that the child of $f(i)$ is $i \in N$
(computed statistically from the Universe)



NACE-Based Model (2)

- The overall model defines the total number of operations of a SC per year generated as a function of:
 - the NACE code
 - the n. of employees in each local unit
- Survey data are used to
 - calibrate the model
 - obtain the distribution of the different attributes (parking type, time of service...) for each SC

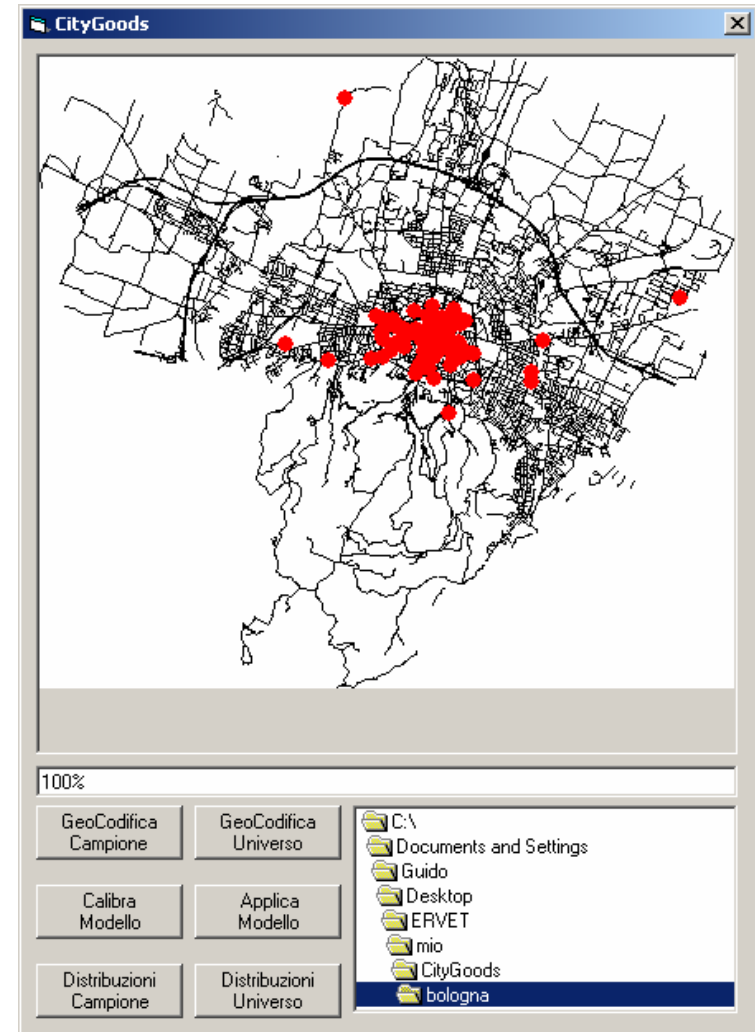


NACE-Based Model (3)

- A spatial model is derived by using
 - user-defined Zones (Cityports Macro-Zones, Transportation studies zones ...)
 - distribution of the Universe in the Zones
 - through geocoding by using a commercial street network (Navteq) available for all towns
 - Municipality-owned GIS ...

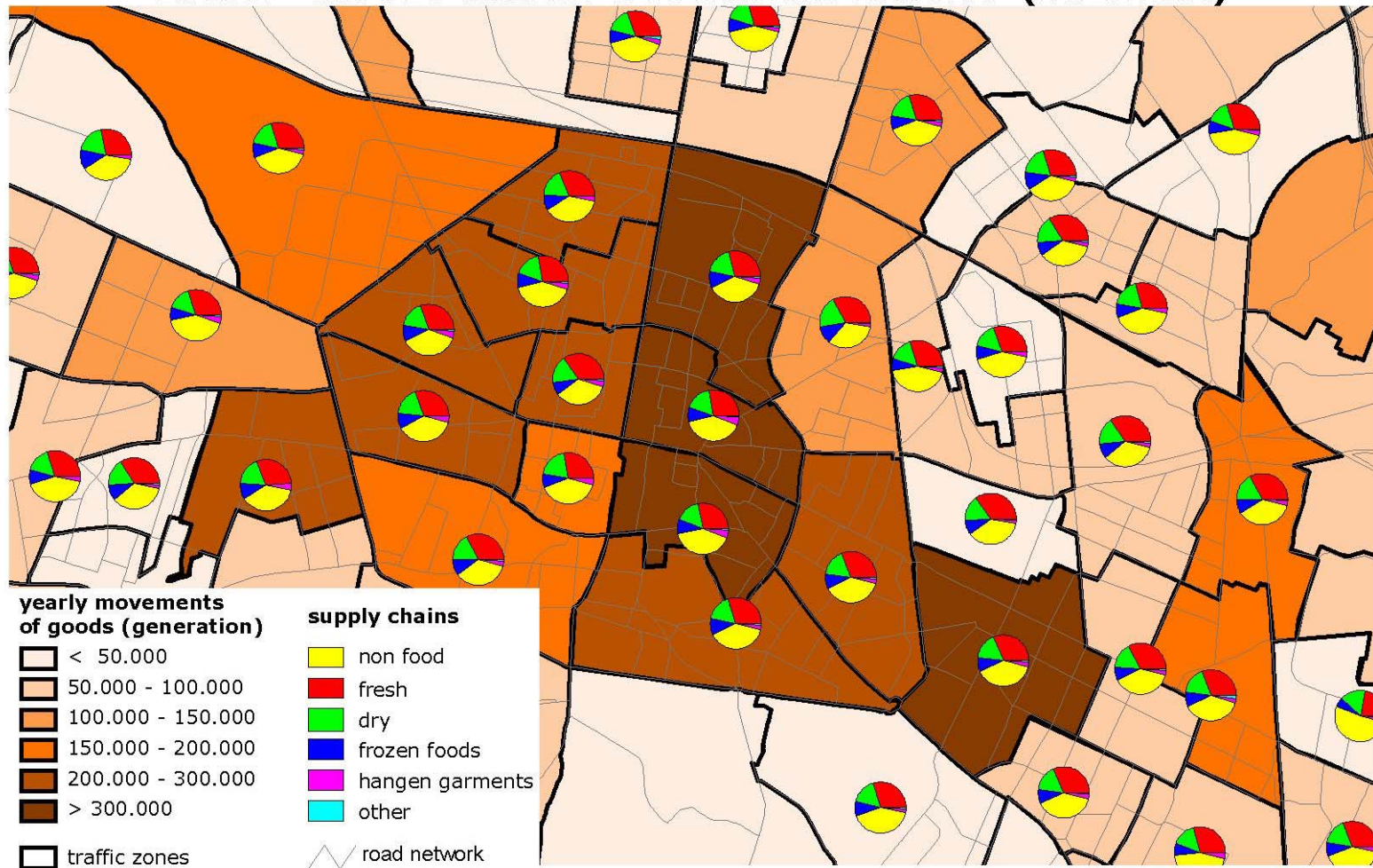
The CityGoods Sw prototype

- CityGoods-Demand
 - Universe and Survey Databases
 - Geocoding local units (sample and Universe)
 - Calibrate the generation model
 - Apply the model to the Universe
 - Export model output (GIS)

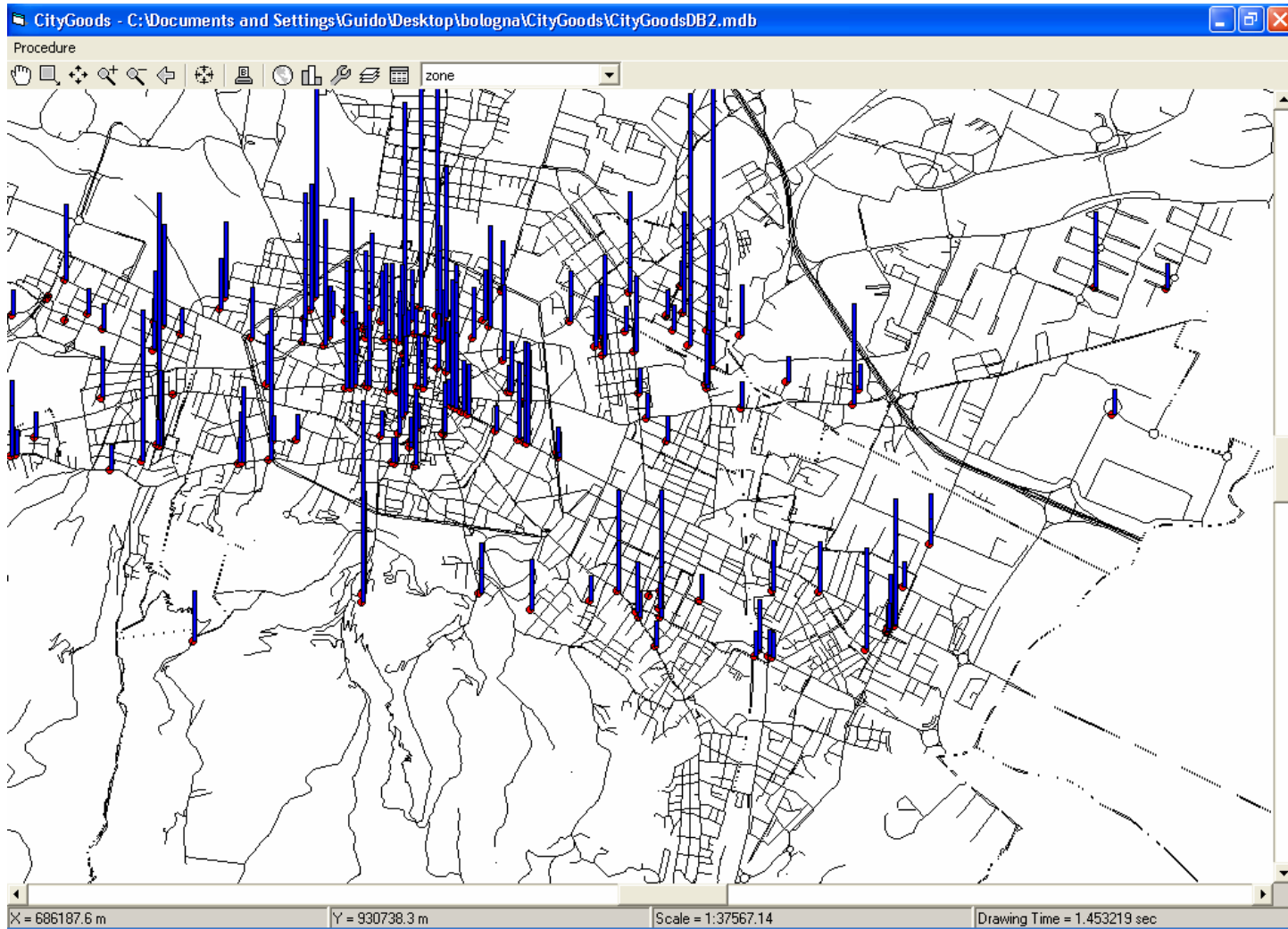


Example: Bologna with SC

ZONES - SUPPLY CHAINS GENERATION MATRIX (BOLOGNA)



New GIS-based interface



New GIS-based interface

CityGoods - C:\Documents and Settings\Guido\Desktop\bologna\CityGoods\CityGoodsDB2.mdb

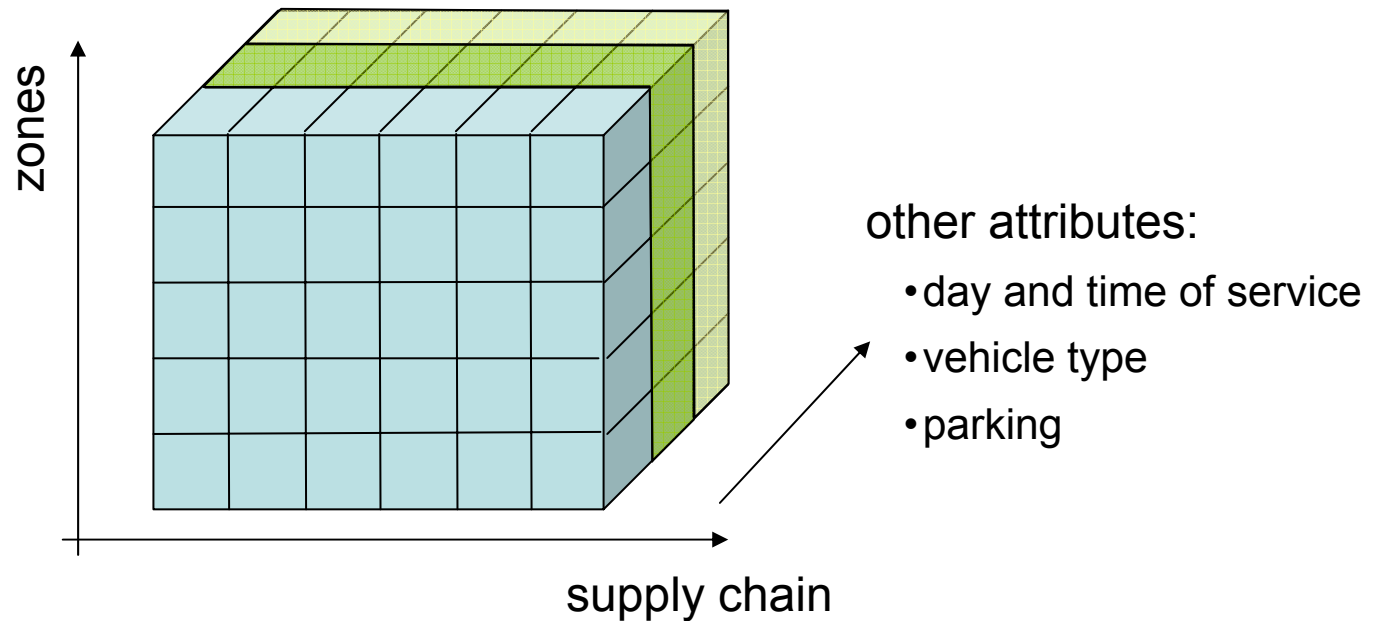
Procedure

- Crea Nuova Base Dati
- Apri Base Dati Esistente
- Importa Stradario
- Importa Zonizzazione
- Geocodifica Campione
- Geocodifica Universo
- Individua Zone del Campione
- Individua Zone dell'Universo
- Calibra Modello di Generazione
- Applica Modello di Generazione
- Calibra Modello di Distribuzione
- Applica Modello di Distribuzione
- Crea Grafo dallo Stradario
- Importa Grafo Stradale
- Applica Modello di Assegnazione

strade

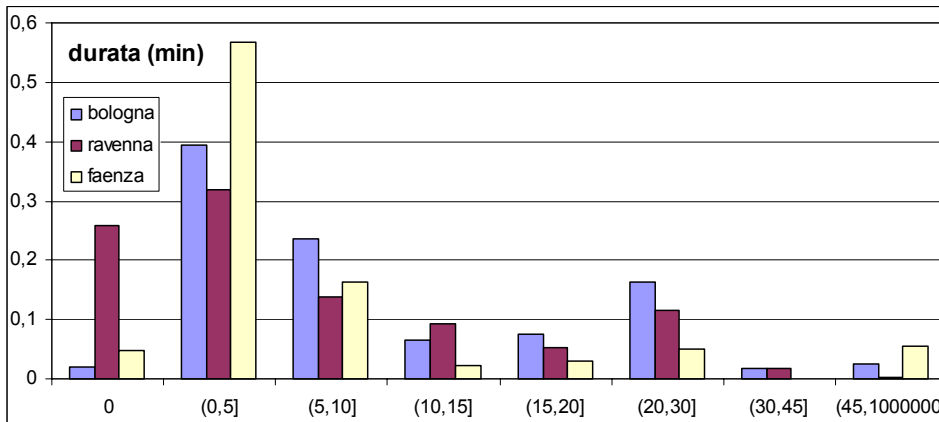
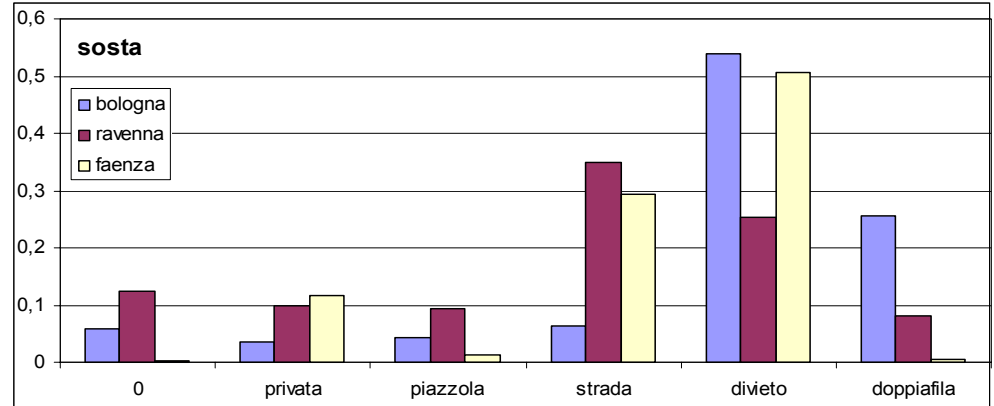
Other SC-related info

- With the SC model we may add several dimensions (different attributes) to the ZS Grid



Other SC-related info (2)

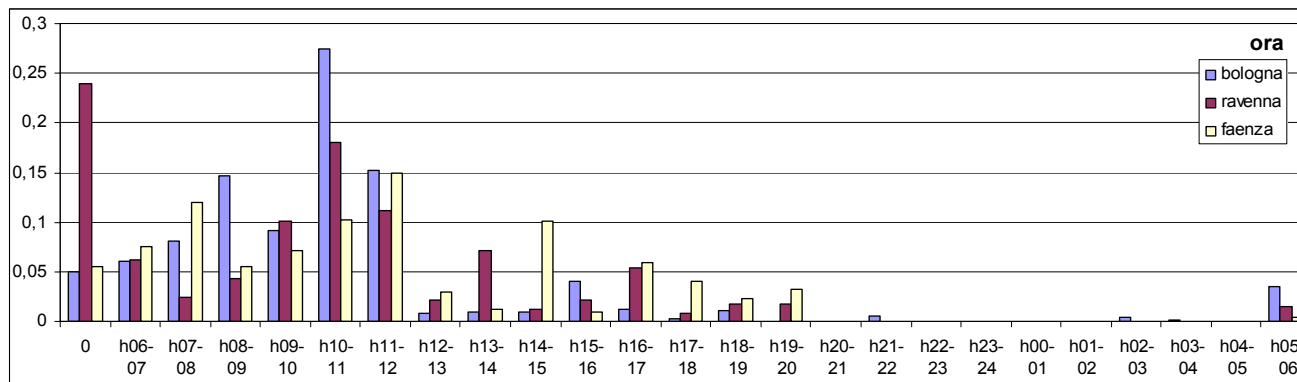
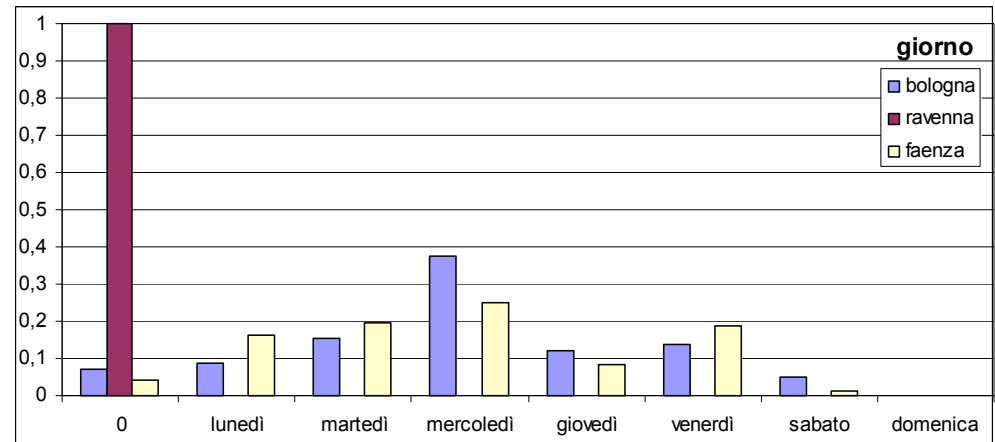
parking type



parking duration

Other SC-related info (3)

service day
and time





Typical Use-Cases

- Construction of the specific model for a given town using “its” surveys
- Construction of the “regional” model using all the surveys (often covering different SCs)



Typical Use-Cases (2)

- Application of the town or regional model to other towns (without additional surveys)
- Requirements:
 - Universe (ISTAT, CCIAA ...)
 - User-defined Zones
 - GIS Cartography o Commercial Street Network



Other CityGoods models

- The NACE-based generation model is the core of a complete set of models:
 - Distribution model
 - Network assignment model
- Developed and tested on various ER towns
- will be soon integrated into City Goods



Application to Bologna





Conclusions ...

- Very effective modeling tool
 - “Soft” data requirements:
 - Simple Universe data, NACE tree, commercial street graphs
 - Fine granularity of results and excellent quality of preliminary testing
 - Easy portability of the model to different towns with/without specific additional surveys



... and Future Work

- Extensive validation of the proposed model with the ER data
 - construction of a Regional model
 - testing on other towns
- Integration of all models into a complete GIS-based software tool (by end 2006)
- Integration with people movement models for purchase purposes



Thank you for your attention

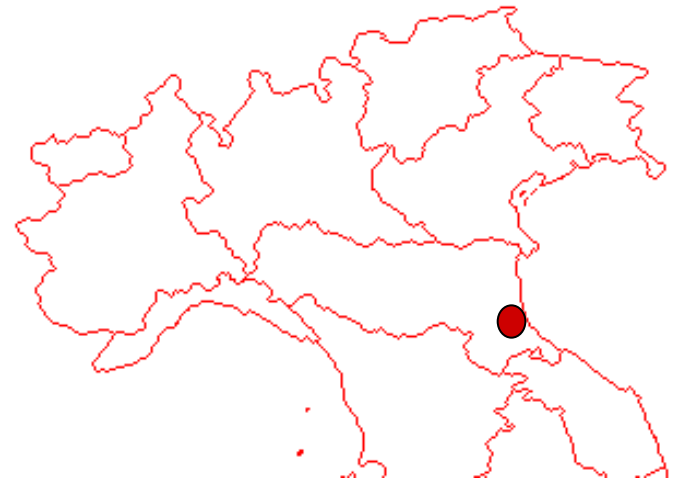


AIRO 2006 Conference

- **Cesena, Italy**

September 12-15, 2006

“urban and regional logistics:
new challenges for modeling
and optimization”



- **Abstract submission deadline: May 29, 2006**
- **Early registration deadline: June 16, 2006**
- **www.airo2006.ingce.unibo.it**