Freight Trip Distribution

FREIGHT TRANSPORT MODELING
(CIVL 7909-8909)

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Overview

- Existing freight models and how distribution fits
  - Growth factors
  - Commodity-based model
  - Trip-based model
  - Tour-based model
  - Logistics-chain model
An inversion problem

Given a set of measurements of shipment movements find an O-D that would produce those measurements

Key question: What type of measurements are needed
OD Estimation Methods

- Maximum Entropy
- Generalized Least Squares
- Bi-level Programming
- (Log)Linear Path Flow Estimation
- Time Dependent Methods
- Utility Maximization (discrete choice models)
- Simulation (more of a solution approach)
Optimization

- All methods are based on optimization problems
- Min/Max problems
- They can be combined
  - Usually with bi-level
  - Upper level estimates costs
  - Lower level estimates flows
Growth Factor

- Forecast truck OD based on
  - Current/past OD
  - Historical trends
  - Economic growth forecasts

- Truck trips as percentage of passenger trips
  - First run travel demand model
  - Estimate truck trips as % of passenger vehicle trips
Commodity, Vehicle Trip, Tour Based

- Similar to 4-step planning process
- Once we have productions and attractions distribute freight
- We will see the pros and cons of each in a second
Basic Freight Distribution Dimensions

- Financial (value)
  - Profit maximizations of each economic agent
- User demands (commodity flows)
  - Supply and Demand of Commodities
- Logistical (vehicle-trips)
  - Result of logistic industry organization to transport commodities
- Models (too advanced/complicated for practice)
  - Game theory
  - Spatial Price Equilibrium models
- Bulk of modeling on Commodity and Vehicle Trips
Vehicle-trips

- Study routing patterns and network impacts
- Do not account for commodities
- Major drawback as commodity type influences
  - Mode choice
  - Vehicle choice
  - Technology adaptation
  - Response to pricing
  - Supply chain selection etc.
Commodity-Flows

Consider:
- Commodity types
- Economics of production and consumption
- Model closely real life processes

No easy way to translate commodity into vehicles

Urban complex patterns with truck trip-chains

Empty trip estimation as a second step
Financial transactions

- **Study economic behavior**
  - Use Input-Output models

- **Issues**
  - Vehicle trip problems similar to commodity based
  - Origin and destination of financial transaction not related to origin-destination of freight (i.e. headquarters in downtown Manhattan, freight moving from Port of New Jersey to upstate NY)
Logistic models

- Regional Logistic Models
  - Logistic decision based
  - Activity-based
  - Joint shipment size and transport choice

- Urban Logistics
  - Four-step
  - Microsimulation

Vehicle tour models
Regional: Logistic Decision Based

- Productions: \( f(\text{Make/Use tables, demand function, shipment value/density, socioeconomic}) \)

- Spatial distribution based on price differences
  - Trade flows = \( f(\text{production chains, logistic costs}) \)
  - Distribution locations = \( f(\text{trade flows, inventory-handling-transport costs}) \)
  - Distribution choice = \( f(\text{distribution locations, inventory-handling-transport costs}) \)
Regional: Activity based

- Production = f(Employment)

- Tour types: f(Sample trips)
  - Collection/distribution tour
  - Consolidation tour
  - Trucking segment
  - Shuttle tours

- Gravity model for distribution of productions to tour type
Regional: Joint shipment size and transport choice

- Production-Consumption from aggregate zonal totals
- Firm flows using number of employees
- Economic order quantity model to estimate shipment sizes
- Transport chains as function of modes, shipment size and flows: Estimate
  - No. of tour legs, mode/vehicle type/loading per unit, transshipment per location per leg)
Urban Logistics Models: Four step

- Volume of goods by zone = \( f(\text{land use, consumer demand}) \)

- Two-step process to find flows
  - Group goods = \( f(\text{spatial choice, supplier choice on volume}) \)
  - Assign mode, vehicle capacity, max load and number of stops as a function of origin activity type
  - Estimate delivery frequency as a function of destination activity type
Urban Logistics Models: MicroSimulation

- Production/Consumption: Regression model

- Fraction of commodity from firm i to customer j: spatial mixed logit model of
  - Distribution channel choice: empirical data
  - Zone choice: spatial mixed logit model
  - Shipper choice: logistic function of commodity production by firm
Vehicle tour models

- Define accessibility measure for each O-D pair (disutility of travel time and distance)

- Number of tours as exponential regression model ($X$: land use, employment, employment accessibility)

- Discrete choice models for tour time

- Assign each tour a purpose, vehicle and start time (Monte Carlo simulation)

- At each stop assign the next stop (logit model)
Four examples

- Tour-based freight origin-destination synthesis
- Commodity-based OD using Input-Output Data
- Multi-commodity O-D synthesis model
- GA based Commodity based OD Approach
Next time

- Pick any paper from the available literature dealing with freight O-D estimation and present in class (20 min presentation)

- The four examples used in class are not qualified

- Look into NCHRP 606 and Chow et al. 2010 for relevant literature
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