A Working Demonstration of a Mesoscale Freight Model for the Chicago Region

presented to

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presented by

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Overview

- Objective of Study
- Evolution of Freight Modeling
- Modeling Steps
- Results
Objective
An Innovative New Freight Model

Regional freight questions (examples)

» How do fuel prices impact mode share?

» Would a new airport relieve congestion at existing airports?

» Would a new intermodal terminal reduce truck drayage?

» How many trucks would use new truck-only lanes?
The Evolution of Freight Models

- Factor Auto Trips
- Truck Trip Generation Rates (QRFM)
- O-D Matrix Estimation
- Disaggregate Commodity Flows
- Truck Touring Models
- Supply Chain and Logistics Models
The CMAP Approach to Advanced Freight Modeling

- **Macroscale Model**
  - Position of the Chicago region in local, national, and global trading arenas

- **Mesoscale Model**
  - Goods movement to/from individual businesses in the Chicago region

- **Microscale Model**
  - Microsimulation of goods movements

Chicago Region

- Diagram showing interactions between the scale models.
Recent Developments in Advanced Freight Modeling

- GoodTrip
- SMILE
- LACMTA Framework
- ADA (2007)
- FAME (2010)
- CMAP (2011)
- DA (2007)
- CMAP (2011)
- FHWA (2012)
CMAP’s Innovative Approach to Freight Forecasting

Agent-Based

Driven by Business Economics
Project Specifications
Fully Functioning Software

```sas
*Enumerates individual firms
****;

data AgentsN5;
  set CBZONEdata;
  by naics6 CBZONE FAPZONEa;
  array e[8];
  do i=1 to 8;
    esizecat=i;
    numerus=e[1];
  output;
  end;
  drop i c1--c8;
run;

data AgentsN5;
  set AgentsN5;
  where numerus>0;
run;

data AgentsN5;
  set AgentsN5;
  by naics6 CBZONE esizecat;
  do i=1 to NumBus; numperm = 1;
end;
```

[Map of urban area with dots representing data points]
Project Specifications (continued)
Meaningful for Analysis of Chicago Region

Legend
- State
- County
- Mesoscale Zones outside of CMAP (FAF3 Zones)
- Mesoscale Zones in CMAP Region
Project Specifications (continued)
Evaluate Transportation Decisions (1)

Rail
Carload, Intermodal (IMX)

Water

Air

Rail-Truck Intermodal
Project Specifications (continued)
Evaluate Transportation Decisions (2)

- Truck with Container
- Truck
  - FTL: Full Truckload
  - LTL: Less-than-Truckload
- Logistics Handling → Transloading, Distribution
Mesoscale Model Overview

1. Firm Synthesis
2. Supplier Selection
3. Apportionment of Commodity Flows
4. Path Selection
5. Prepare for Assignment
Generate Individual Firms

* Characterize firms – Buyer? Supplier? Both?
* Identify top commodities traded
* Wholesale firms – simulate type of goods traded
Firm Location Model

**CBP Data at County Level**
- 2 firms with 1-10 employees
- 1 firm with 100-250 employees

**Simulate Mesozone Location**
1. Firm #1 in Mesozone 23
2. Firm #2 in Mesozone 57
3. Firm #3 in Mesozone 59

**CMAP Land Use Data**
Supplier Selection

- Identify **potential** trading partners (FAME)
  - Utilizes information from Input-Output Make and Use Table (Bureau of Economic Analysis)
  - Candidate partners must be part of Macroscale commodity flow table

- Supply chain formation
  - Each buyer selects a supplier
  - Model with asserted parameters (based on FAME formulation)

<table>
<thead>
<tr>
<th>Consumer Business Size (Number of Employees)</th>
<th>Producer Business Size (Number of Employees)</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 to 99</td>
<td>100 to 499</td>
</tr>
<tr>
<td>1 to 99</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>100 to 499</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td>500+</td>
<td>0.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Flow Apportionment

- **Input** – aggregate commodity flows

- **Disaggregate flows among supplier-buyer pairs**
  - Based on buyer firm size (number of employees)
  - Tons of goods consumed per buyer firm employee by industry (derived from Make-Use table)

- **Output** – annual tons traded between supplier and buyer
Path Selection

**Inputs**

- Path information from model network
- Annual transport and logistics cost formulation
  - Ben-Akiva and de Jong (ADA)
  - Shipment frequency
  - Travel time and reliability needs
  - Loss and damage

**Each supply chain selects a transport and logistics path for its shipping needs**
Prepare for Assignment

Key output – freight vehicle trip table by:

» Commodity

» Shipment size

» Shipment frequency

» Mode (truck, rail, air, water) and submode (TL, container, etc.)

» Origin TAZ, destination TAZ, and intermediate logistics stop nodes
SUPPLY CHAIN EXAMPLE
Supply Chain Example
Consumer Goods from Overseas Manufacturer to Retailers

Input Flows from Macroscale Model

Origin (East Asia)  FAF Tons  Chicago FAF Zone
Supply Chain Example
Consumer Goods from Overseas Manufacturer to Retailers

Generate Firms

East Asia Manufacturers ➔ FAF Tons ➔ Chicago-Area Retail Stores
Supply Chain Example
Consumer Goods from Overseas Manufacturer to Retailers

Form Supply Chains

East Asia Manufacturers

Chicago-Area Retail Stores

FAF Tons
Supply Chain Example
Consumer Goods from Overseas Manufacturer to Retailers

Apportion Flows Among Supply Chains

East Asia Manufacturers → FAF Tons → Chicago-Area Retail Stores
Supply Chain Example
Consumer Goods from Overseas Manufacturer to Retailers

Path Selection Overview
Supply Chain Example
Consumer Goods from Overseas Manufacturer to Retailers

International Origin
Overseas Factory → Overseas Port

Port and Its Vicinity
U.S. Port → Rail Terminal
Rail Terminal → Transload Center
Transload Center → Warehouse/DC
Warehouse/DC → Retail Store

Chicago Area
Rail Terminal → Warehouse/DC
Warehouse/DC → Retail Store
Evaluation of Transport and Logistics Decisions: Path Enumeration

Example:

Port of Los Angeles to Chicago

Shipment Size: 140 tons in seven 40’ containers

Option B: Transload to intermodal yard in Chicago area, then truck

Composite cost: $10,763

$6,825 $438 $3,500

$17,500 – $14,925 = $2,575

$17,500 – $15,713 = $987
Evaluation of Transport and Logistics Decisions: Path Selection

Option A: Truck hauls container entire distance

Option B: Transload then Truckload

Option C: Intermodal rail to intermodal yard in Chicago area, then Truck

Option A: Composite cost: $17,500
Option B: Composite cost: $15,713
Option C: Composite cost: $10,763
EXAMPLE RESULTS
Example Results
Percentage of Goods by Path Type

Example Results: Rail – Air – Water Ports
Number of Shipments

Example Results: Rail – Air – Water Ports

Less than Truckload Drayage Trucks

Example Results: Rail – Air – Water Ports

*Full Truckload* Drayage Trucks

Summary and Next Steps

- The CMAP Mesoscale Model
  - Leading edge of freight modeling tools
  - Agent-based approach to modeling freight movements
  - Driven by economic principles
  - Generate insights into broad range of questions

- Model enhancements
  - Data collection
    - Stated preference surveys of businesses
    - Path cost data
  - Model calibration and validation
QUESTIONS?