

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

*presented to*

**CMAP Advanced Modeling  
Pre-Symposium Webinar**

*presented by*

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*with*

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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



# The CMAP Approach to Advanced Freight Modeling

## Macroscale Model

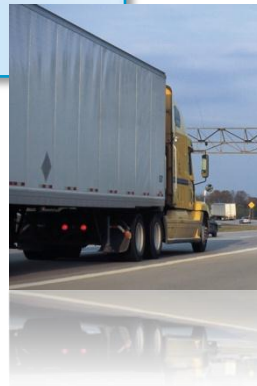
- Position of the Chicago region in local, national, and global trading arenas

## Mesoscale Model

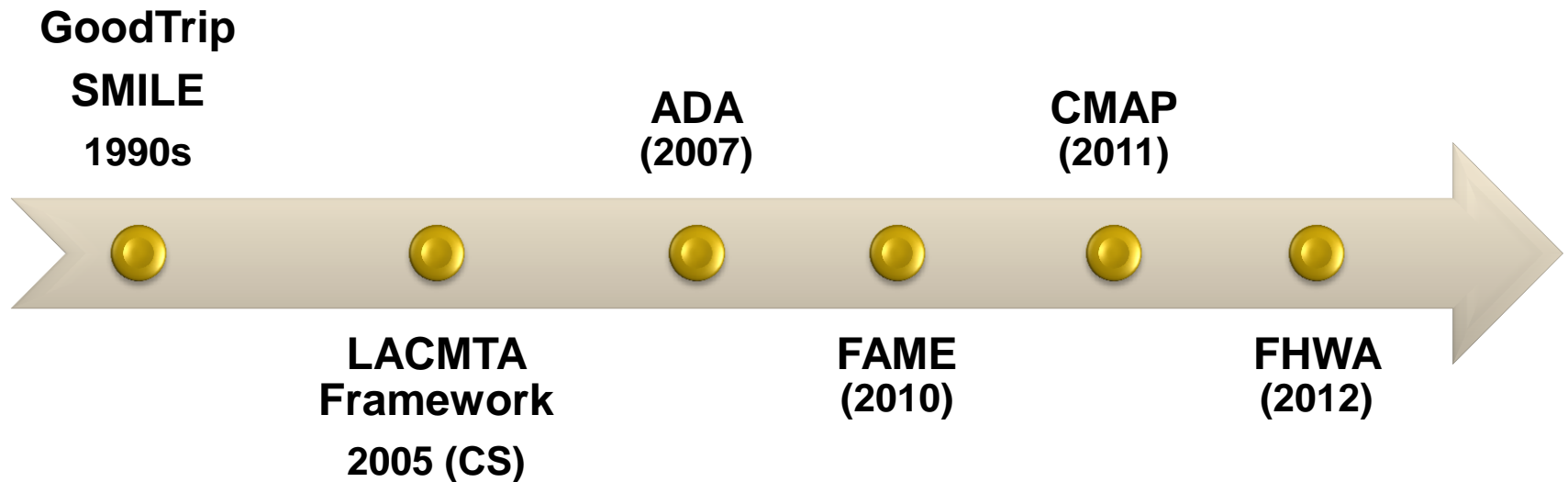
- Goods movement to/from individual businesses in the Chicago region

## Microscale Model

- Microsimulation of goods movements



# Recent Developments in Advanced Freight Modeling



# CMAP's Innovative Approach to Freight Forecasting



**Agent-Based**



**Driven by Business Economics**

# Project Specifications

## Fully Functioning Software

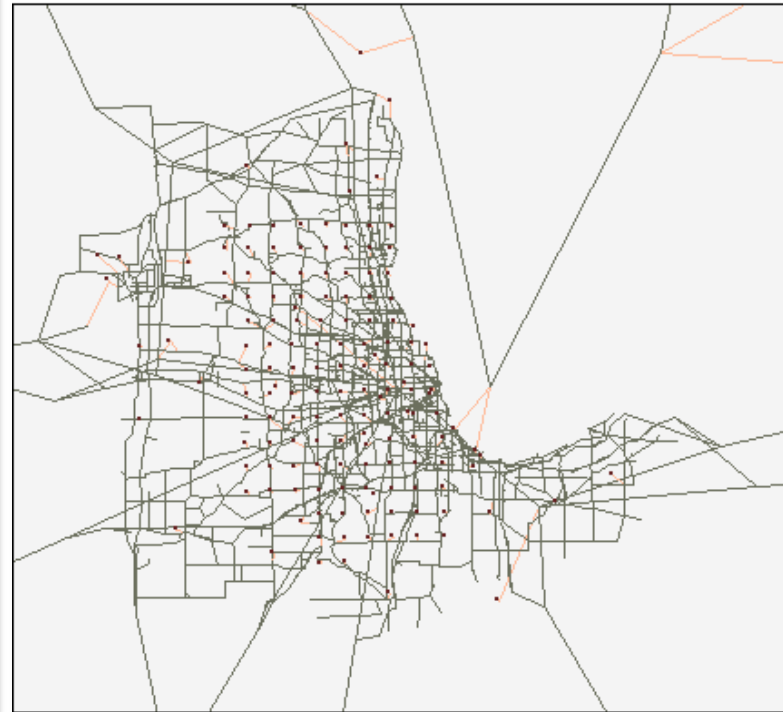
```
SAS - [Meso 29_Annotated.sas]
File Edit View Tools Run Solutions Window Help

****
Enumerate individual firms
****;

data AgentsN6 ;
set CBPZONEdata ;
by naics6 CBPZONE FAFZONEa ;
array e[8] ;
do i=1 to 8 ;
  esizecat=i;
  numbus=e[i];
output;
end;
drop i e1--e8 ;
run;

data AgentsN6;
set AgentsN6;
where numbus>0;
run;

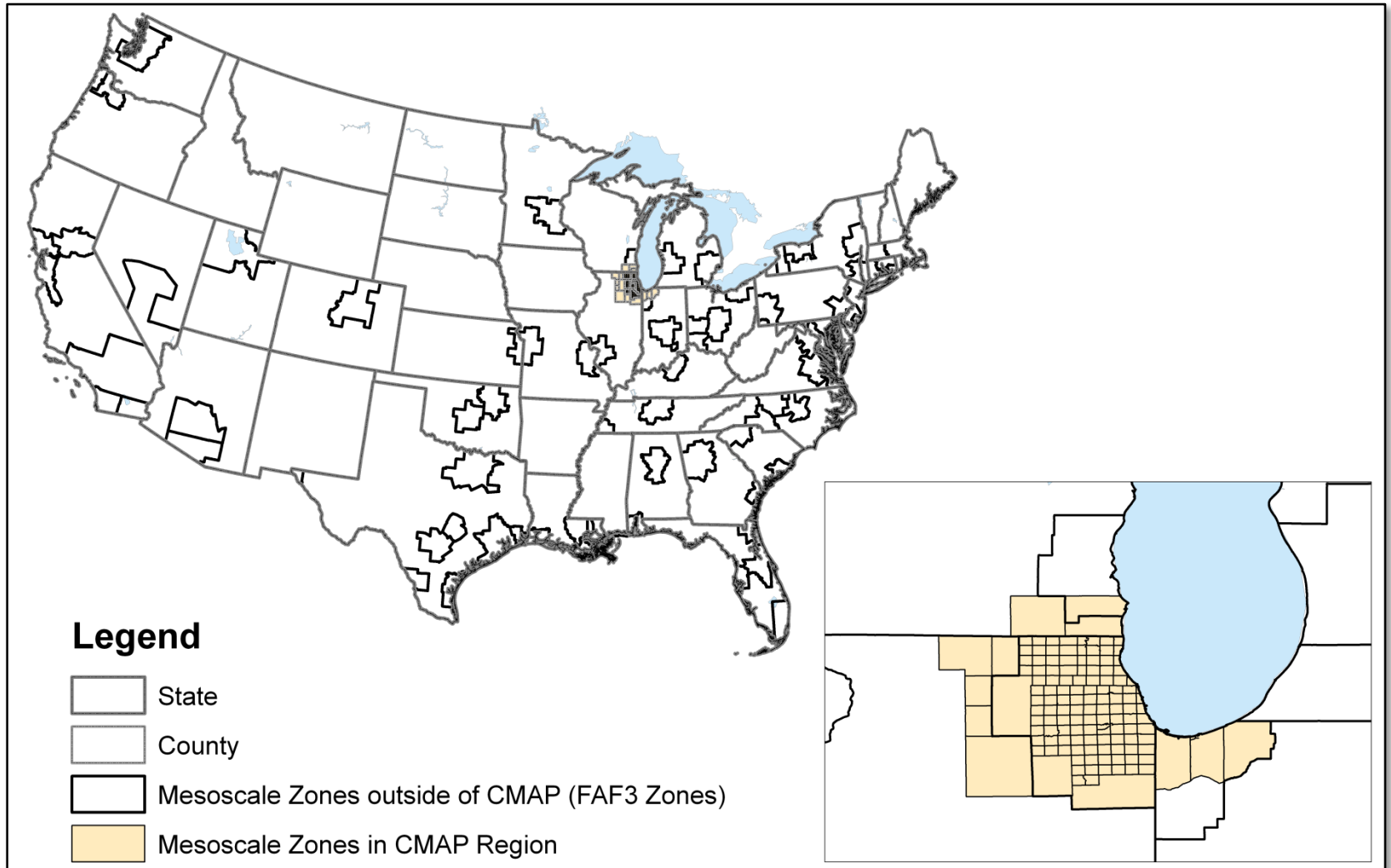
data AgentsN6;
set AgentsN6;
by naics6 CBPZONE esizecat ;
do i=1 to NumBus ;
  numera = i;
```





# Project Specifications (continued)

## Meaningful for Analysis of Chicago Region



# Project Specifications (continued)

## Evaluate Transportation Decisions (1)



**Rail**  
Carload, Intermodal (IMX)



**Water**



**Rail-Truck Intermodal**



**Air**

# 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**

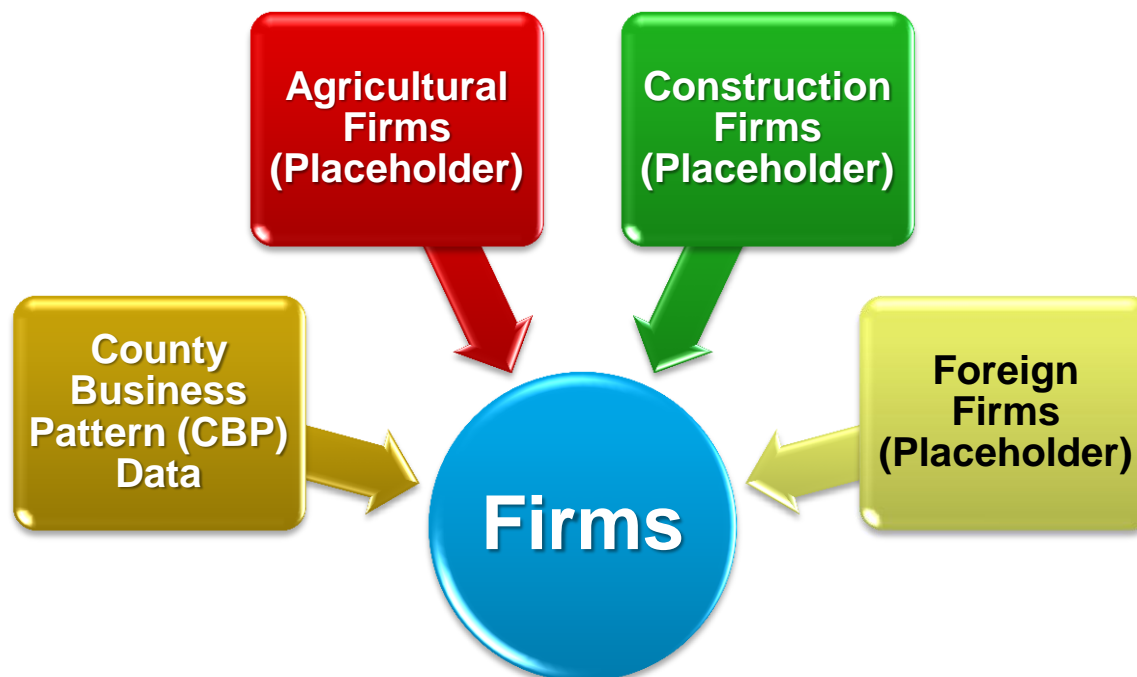
**2 Supplier Selection**

**3 Apportionment of Commodity Flows**

**4 Path Selection**

**5 Prepare for Assignment**

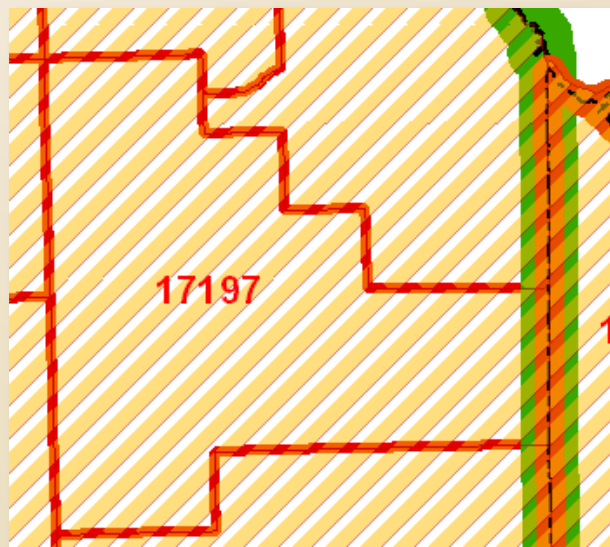
# Generate Individual Firms



- \* **Characterize firms – Buyer? Supplier? Both?**
- \* **Identify top commodities traded**
- \* **Wholesale firms – simulate type of goods traded**

# Firm Location Model

## CBP Data at County Level

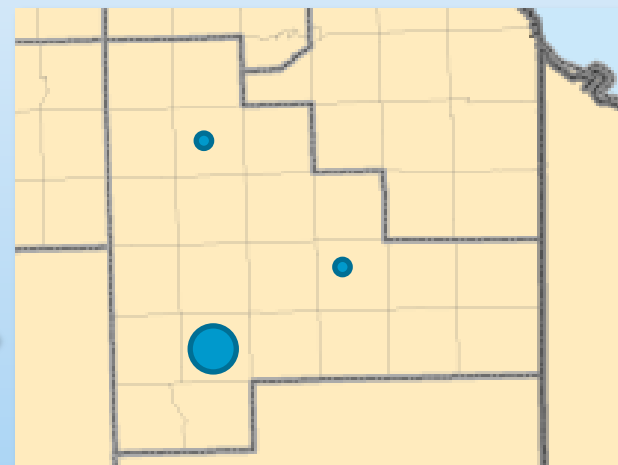


- 2 firms with 1-10 employees
- 1 firm with 100-250 employees

CMAP  
Land Use  
Data



## Simulate Mesozone Location



1. Firm #1 in Mesozone 23
2. Firm #2 in Mesozone 57
3. Firm #3 in Mesozone 59

# 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)

Consumer Business Size (Number of Employees)	Coefficient							
	Producer Business Size (Number of Employees)			Great Circle Distance Between Consumer and Producer (Miles)				
	1 to 99	100 to 499	500+	Over 1,509	596 to 1,509	150 to 595	1 to 149	0 (Intracounty)
1 to 99	0.2	0.2	0.4	-0.4	-0.3	-0.2	0	0.1
100 to 499	0.2	0.6	0.6	-0.2	-0.1	-0.05	0	0.1
500+	0.4	0.6	0.6	-0.1	-0.05	0	0	0.1

# 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

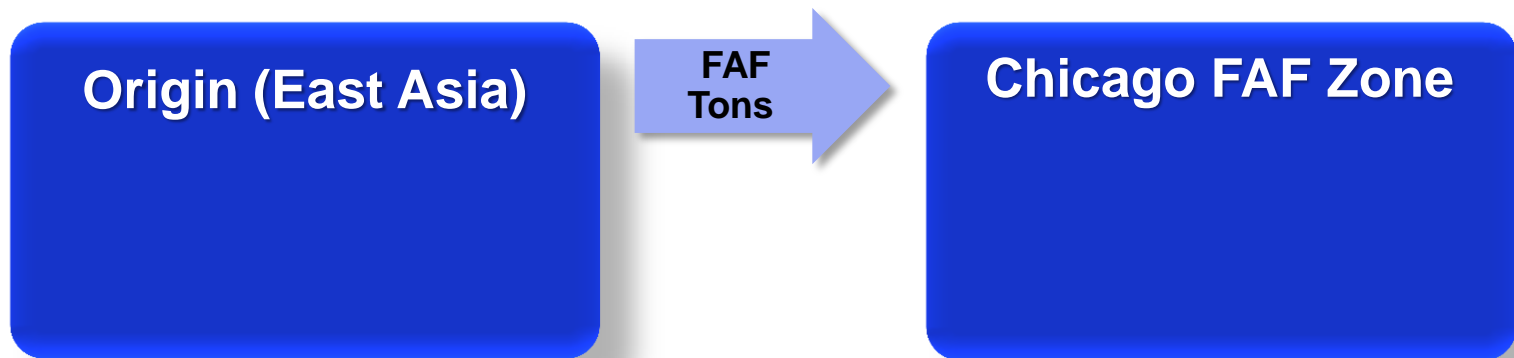
- **Key output – freight vehicle trip table by:**
  - » **Commodity**
  - » **Shipment size**
  - » **Shipment frequency**
  - » **Mode (truck, rail, air, water) and submode (TL, container, etc.)**
  - » **Origin TAZ, destination TAZ, and intermediate logistics stop nodes**

# **SUPPLY CHAIN EXAMPLE**

# Supply Chain Example

## Consumer Goods from Overseas Manufacturer to Retailers

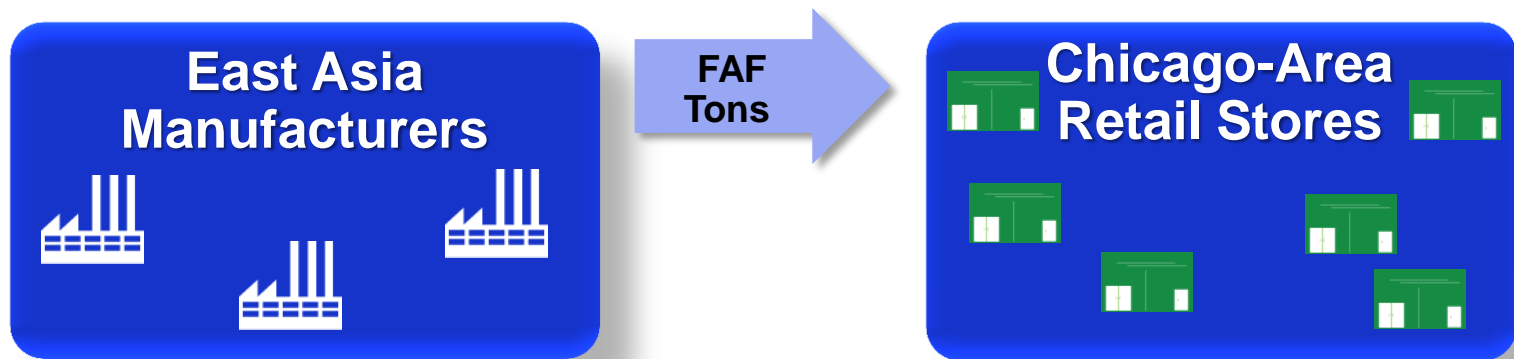
### Input Flows from Macroscale Model



# Supply Chain Example

## Consumer Goods from Overseas Manufacturer to Retailers

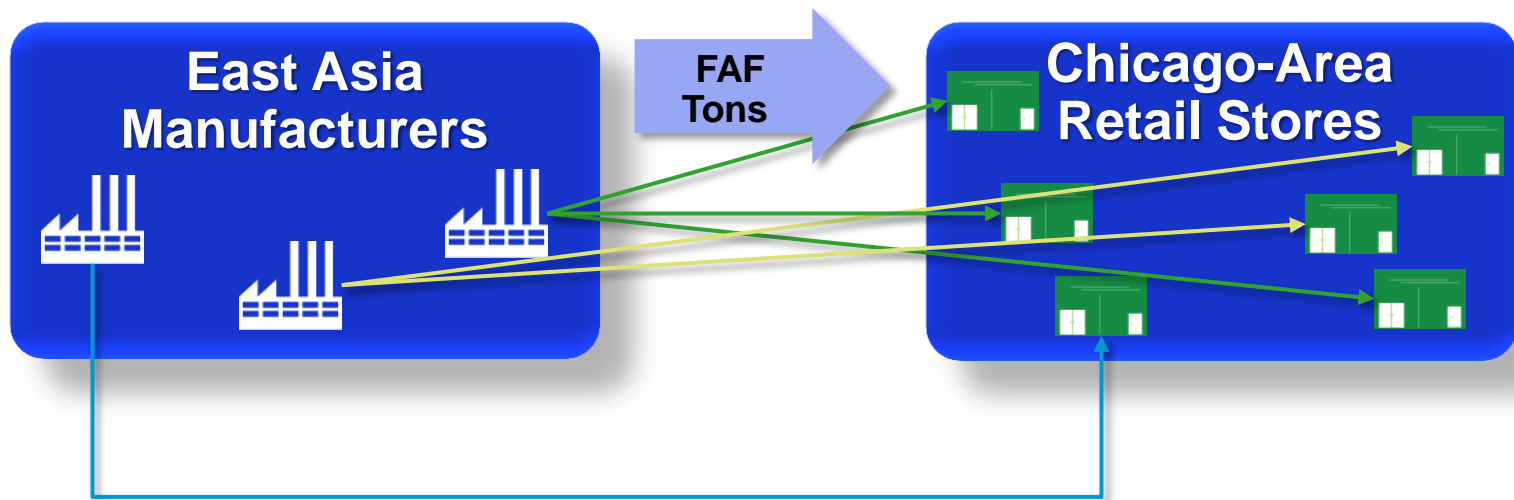
### Generate Firms



# Supply Chain Example

## Consumer Goods from Overseas Manufacturer to Retailers

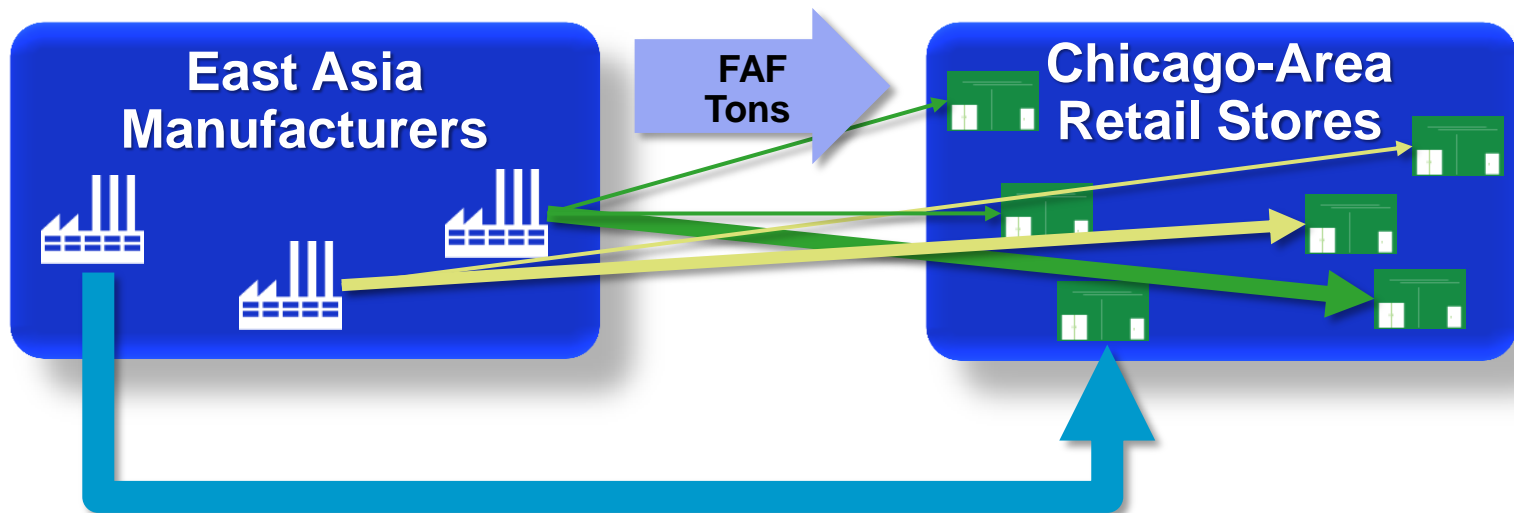
### Form Supply Chains



# Supply Chain Example

## Consumer Goods from Overseas Manufacturer to Retailers

### Apportion Flows Among Supply Chains



# Supply Chain Example

## Consumer Goods from Overseas Manufacturer to Retailers

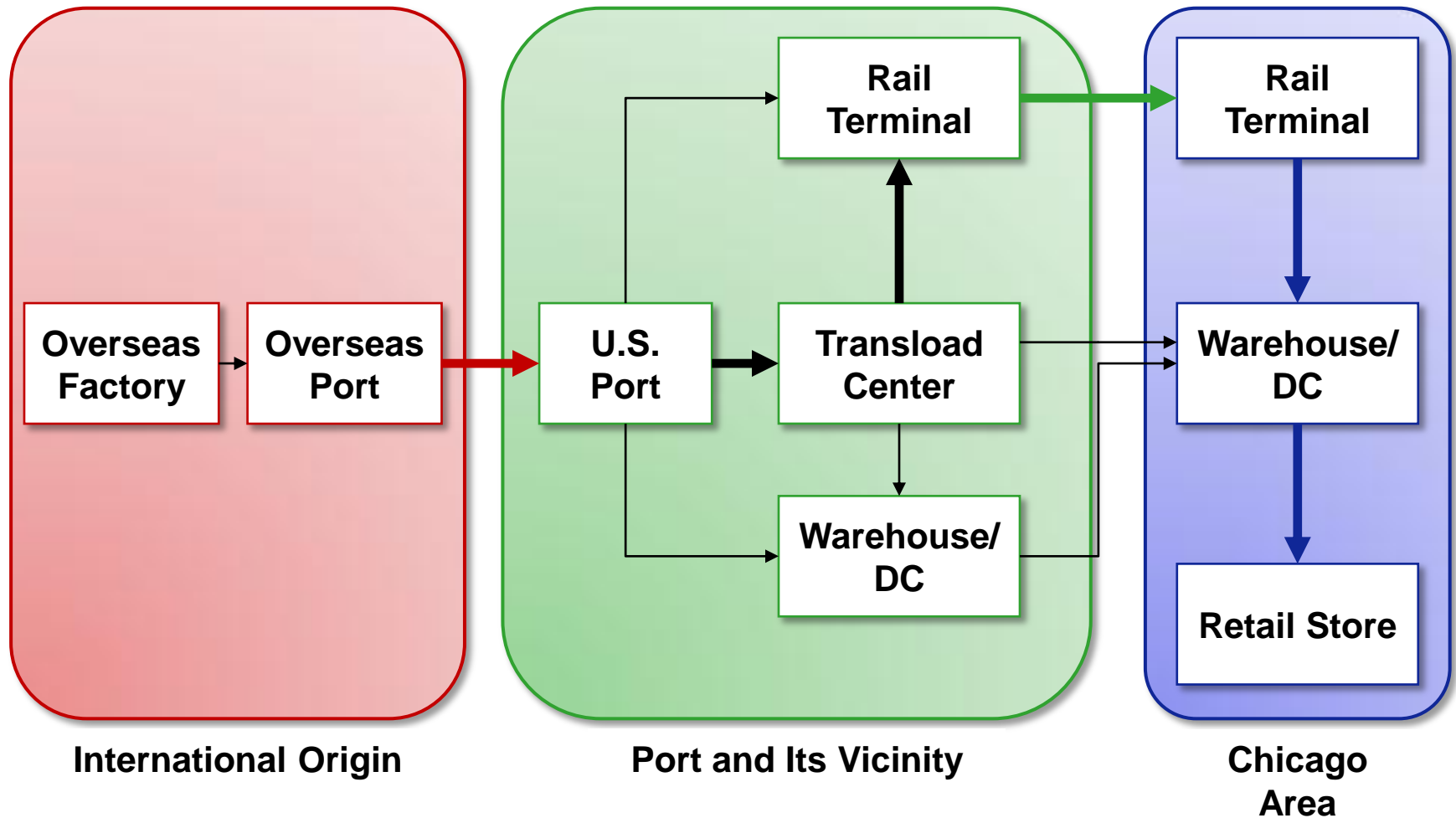
### Path Selection Overview





# Supply Chain Example

## Consumer Goods from Overseas Manufacturer to Retailers



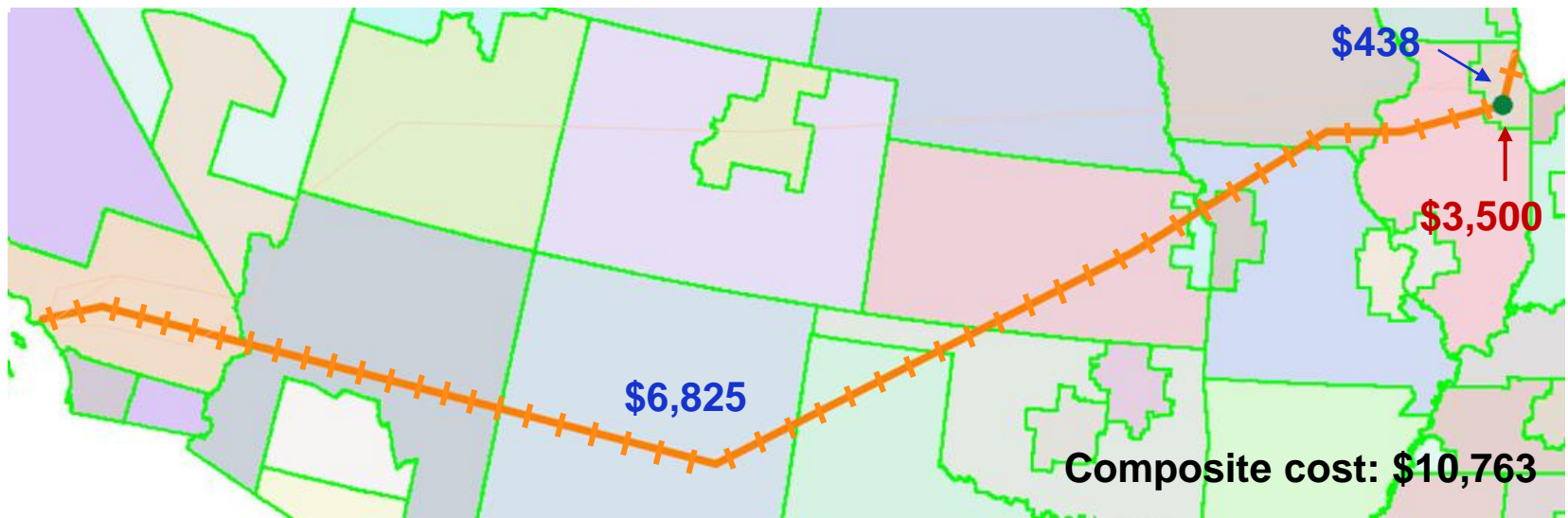
# Evaluation of Transport and Logistics Decisions: Path Enumeration

Example:

Port of Los Angeles to Chicago

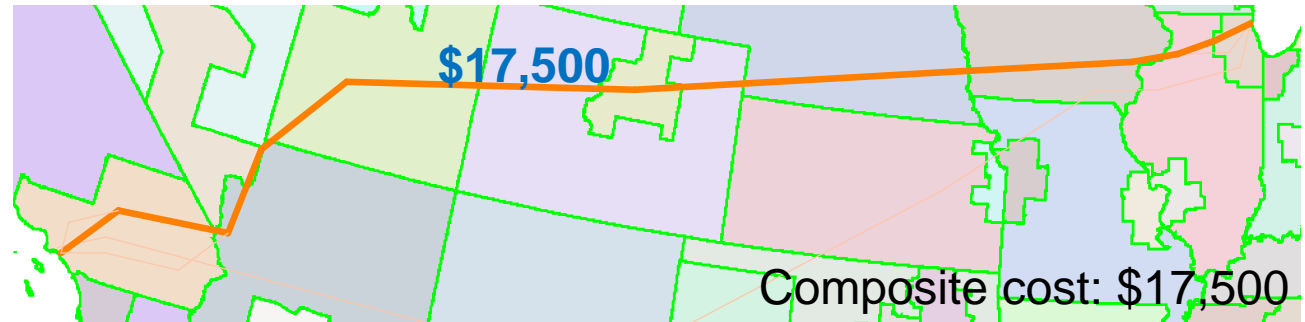
Shipment Size: 140 tons in seven 40' containers

Option B: ~~Transfer their containers to a rail yard in Chicago~~ Transfer their containers to a rail yard in Chicago area, then truck

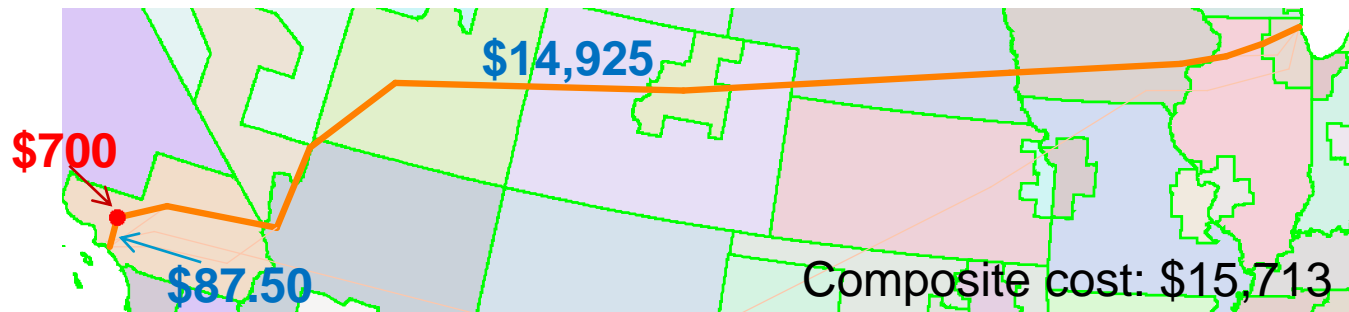


# Evaluation of Transport and Logistics Decisions: Path Selection

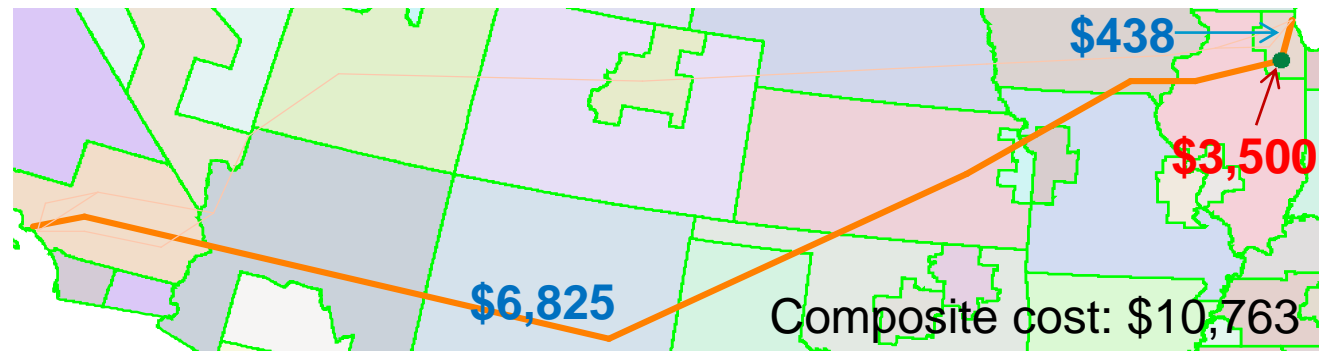
**Option A:** Truck hauls container entire distance



**Option B:** Transload then Truckload



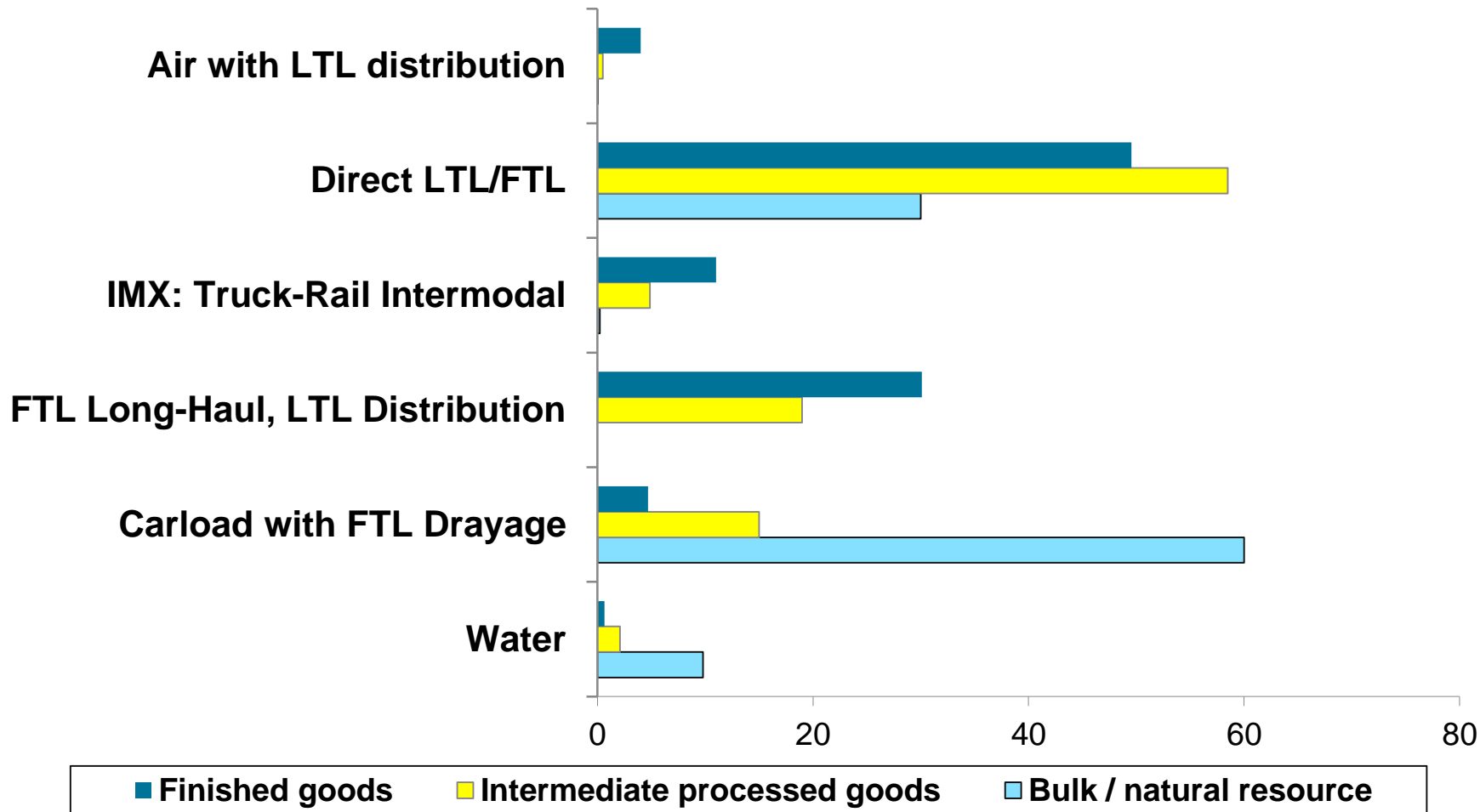
**Option C:** Intermodal rail to intermodal yard in Chicago area, then Truck



# EXAMPLE RESULTS

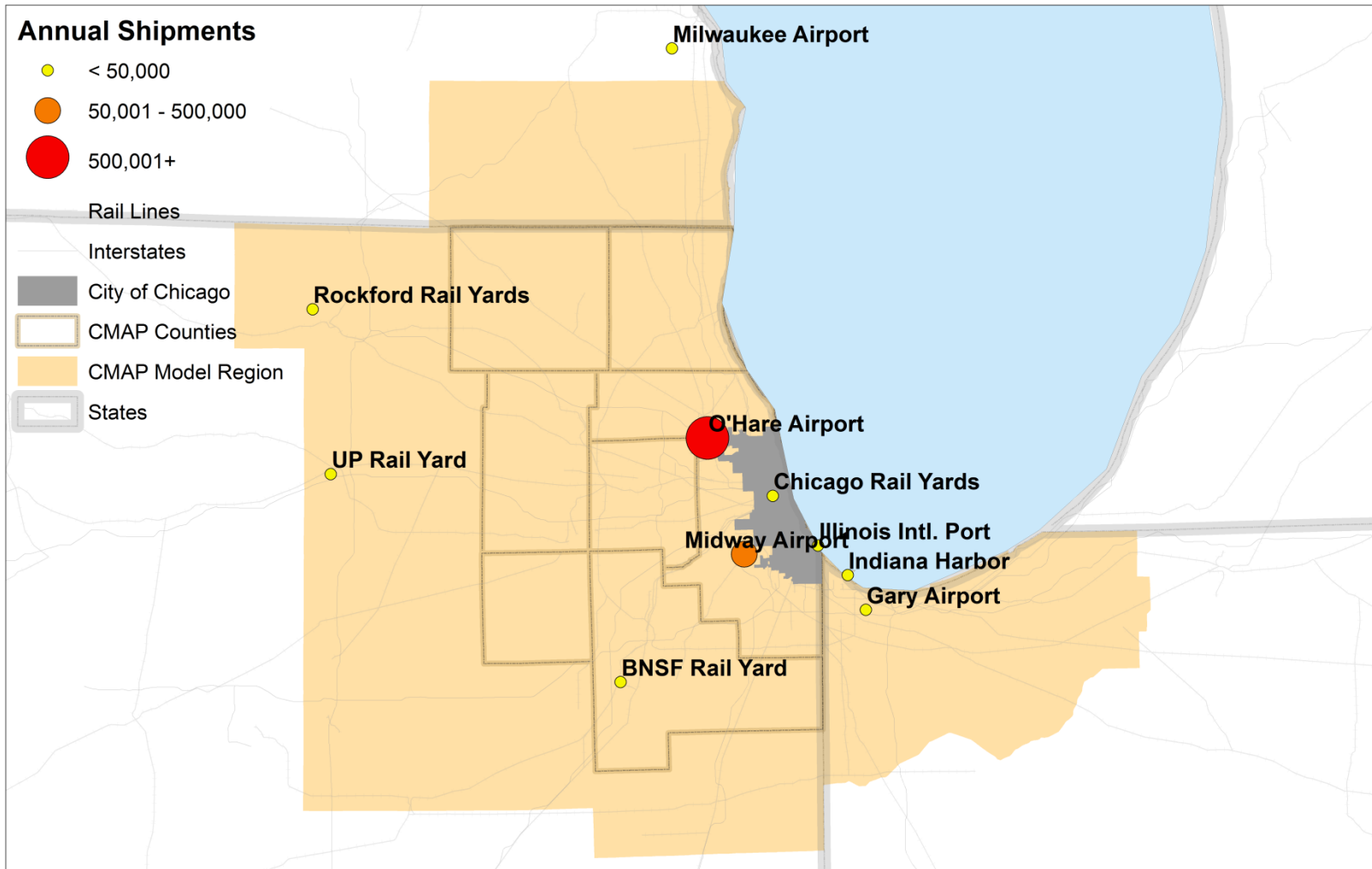
# Example Results

## Percentage of Goods by Path Type



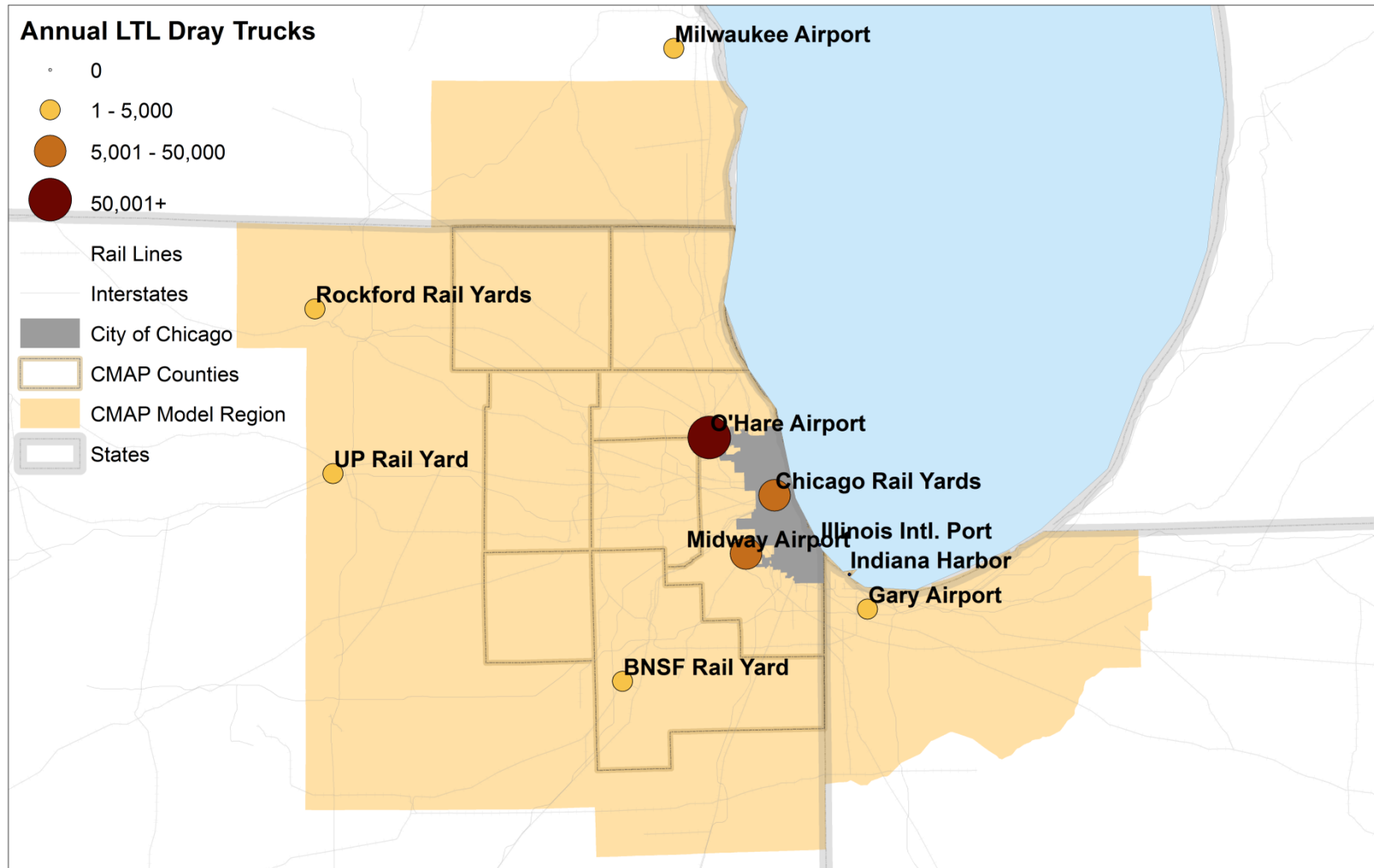
Source: CMAP Mesoscale Model (2011).

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



Source: CMAP Mesoscale Model (2011).

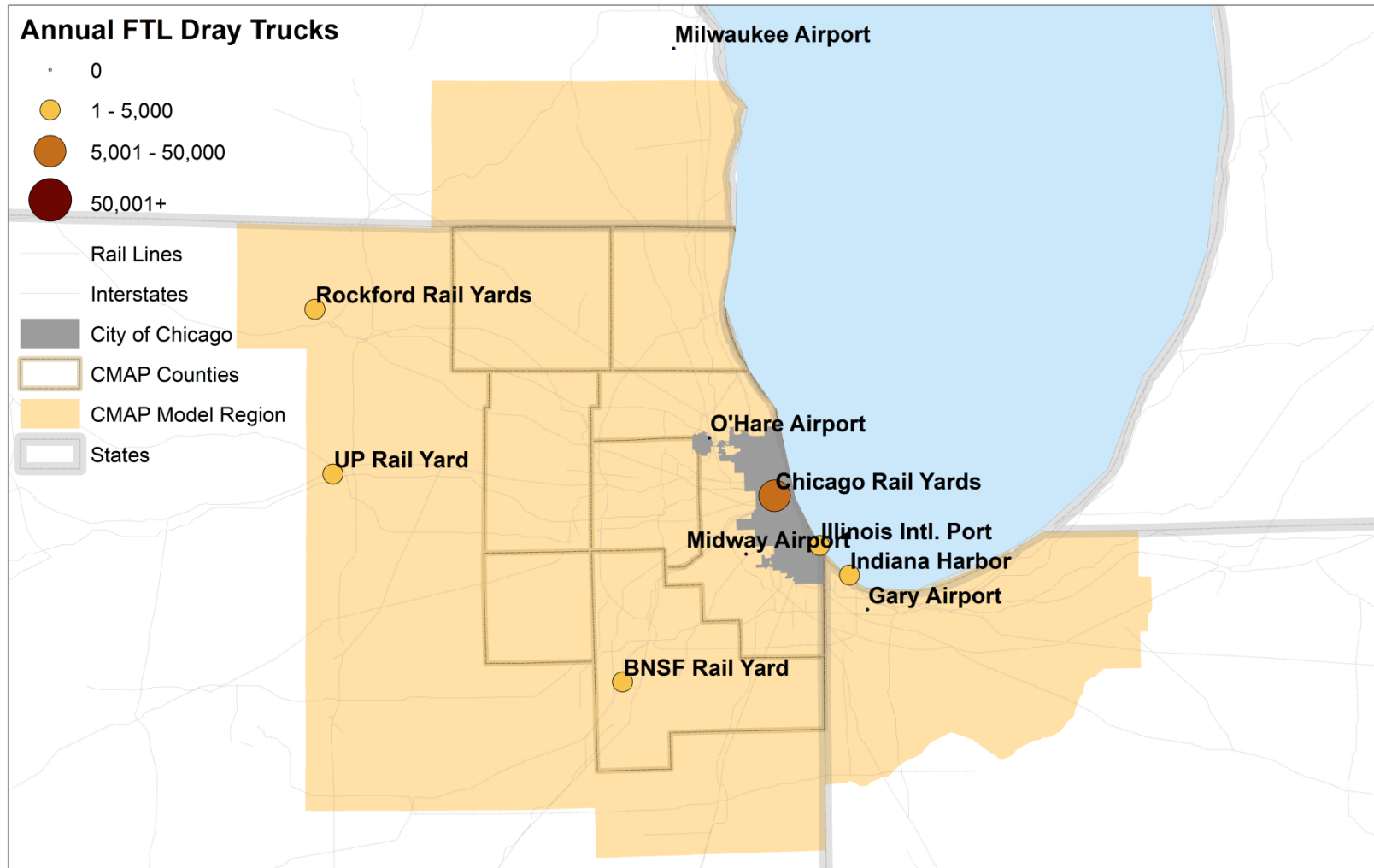
# Example Results: Rail – Air – Water Ports *Less than Truckload Drayage Trucks*



Source: CMAP Mesoscale Model (2011).

# Example Results: Rail – Air – Water Ports

## Full Truckload Drayage Trucks



Source: CMAP Mesoscale Model (2011).



# 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?**