Florida Multimodal Statewide Freight Model

Model inputs and structure, and integration with regional truck-touring models

Presented by Colin Smith, RSG
Florida has a large, complex, multimodal freight transportation system:

- 15 deep water seaports (international trade moving through Florida’s ports was valued at $56.9 billion in 2009)
- 2,786 miles of rail lines carried 1.6 million carloads and 83 million tons of freight in 2008
- Miami International Airport first in the nation in total international freight tonnage
- Strategic Intermodal Systems Highways cover 4,300 miles of roadway and carry the majority of the state highway system’s truck traffic

Issues include how to manage and invest in the system to meet statewide objectives:

- For example – SIS objectives: economic competitiveness, interregional connectivity; efficiency; choices; intermodal connectivity; energy, air quality, and climate; and emergency management and safety
Motivation for the Model

Enhance Florida’s statewide freight forecasting capabilities

AND

Provide a framework to support enhancements to regional freight forecasting

- New model is multi-modal
- Includes updated commodity flow information
- More detailed framework: additional policy sensitivity
  - Represent characteristics of firms and shipments
  - Represent supply chains and distribution channels
  - Capture trip-chaining that occurs
The freight model is implemented in R and Cube. Cube provides the overall structure, skimming and assignment, and gives control to R which runs the demand model components via a command line window.
Firm Synthesis

Synthesizes a list of businesses in Florida, the rest of the US, and an international sample

Supplier Selection

Connects suppliers to buyers based on the commodities produced by the supplier and consumed by the buyer

Goods Demand

Distributes commodity flows amongst the paired suppliers and buyers

Distribution Channel

For each buyer/supplier pair, selects whether shipments are direct or involve intermediate handling (intermodal, distribution center)

Shipment Size

For each buyer/supplier pair, converts an annual commodity flow to shipments by size and frequency

Mode and Transfers

Identifies the mode for each leg of the trip from supplier to buyer and the transfer locations

Network Assignment

Assign the trips to the multi-modal networks based on the mode(s) and transfer locations
What is “firm synthesis”?

- A model that creates a complete set of “agents” that represent firms
- The model embodies each of those firms with individual characteristics that affect the behavior that we are interested in modeling:
  - Where are they located?
  - How large is the firm?
  - What industry do they operate in?
  - Which commodities do they consume?
  - Which commodities do they produce?

- Concept is similar to population synthesis used in activity-based models
  - In this case, households are the agents that are created
  - They are described in terms of location, size, etc.
What is “supplier selection”?

- Model to establish business relationships between producers (suppliers) of goods and consumers (buyers) of goods

- Data
  - FAF industry to commodity crosswalk, to determine type and percentage of produced commodity by each industry type
  - Make and use tables in the 2007 Benchmark Input-Output Account, to determine type and percentage of commodities used by each industry
  - Firms’ characteristics and amount of incoming and outgoing commodities are from the first module

- Rule-based system:
  - Uses “Distance” and “Establishment size of both supplier and buyer” as the input criteria for assessing the suitability of candidate suppliers
  - The output is the probability of partnership for each pair of supplier-buyer
  - The firms with the highest probability of partnership will be selected as the best suppliers
Individual firms are synthesized in each traffic analysis zone (TAZ) based on employment data for each industry (County Business Patterns, InfoUSA, QCEW, and other local data).

TAZs provide detailed spatial resolution, particularly in metropolitan areas, for firm locations and shipment origins and destinations.

Across the whole of Florida, the TAZs provide a significant level of detail.

FAF commodity flow data, a model input, uses large FAF zones. This is disaggregated down to TAZs based on the firm allocations and economic (input/output) data.
<table>
<thead>
<tr>
<th>Commodity Category</th>
<th>Weight (Kt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal n.e.c.</td>
<td>2,000</td>
</tr>
<tr>
<td>Nonmetal minerals</td>
<td>1,500</td>
</tr>
<tr>
<td>Plastics/rubber</td>
<td>1,000</td>
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<tr>
<td>Articles-base metal</td>
<td>750</td>
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<tr>
<td>Basic chemicals</td>
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<td>Other foodstuffs</td>
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<td>Chemical products</td>
<td>200</td>
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<tr>
<td>Fertilizers</td>
<td>100</td>
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<tr>
<td>Other ag products</td>
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<tr>
<td>Base metals</td>
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<tr>
<td>Milled grain products</td>
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<td>Wood products</td>
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<tr>
<td>Meat/seafood</td>
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<tr>
<td>Textiles/leather</td>
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<tr>
<td>Mixed freight</td>
<td>0.1</td>
</tr>
<tr>
<td>Other Commodities</td>
<td>0</td>
</tr>
</tbody>
</table>

**Commodities by Mode (Weight in Kt in 2007)**

- Air (include truck-air)
- Multiple modes & mail
- Other and unknown
- Pipeline
- Rail
- Truck
- Water

**Florida (2007)**

Top 20 Origins (Kt)
- 1,000
- 10,000
- 101 - 500
- 501 - 1,000
- 1,001 - 2,500
- 2,501 - 5,000
- 5,001 - 10,000
- 10,001 - 12,500

**Total Freight Flow (Kt)**
- 1 - 100
- 101 - 500
- 501 - 1,000
- 1,001 - 2,500
- 2,501 - 5,000
- 5,001 - 10,000
- 10,001 - 12,500

Houston to Florida Map showing freight flows to the state.
Model Geography: Transportation Networks

- Model covers all of Florida and includes transportation networks across the USA and internationally.
- Uses newest multi-modal transportation networks: highway, rail, seaports and waterways, airports, and intermodal connections.
- Uses network information to understand transportation costs (including storage costs during transshipment), capacities, and resulting travel times.
- Model outputs vehicle and commodity flows on networks and through intermodal/distribution centers.
Shipments are assigned to the following modes:

- Truck (full truck load, less than truck load)
- Rail (carload, intermodal)
- Water (international, non-international)
- Air

Paths for shipments with complex distribution channels, i.e., that are not direct from shipper to buyer, can use a single mode or be multimodal, e.g.:

- Truck – Truck
- Truck – Rail – Truck
- Truck – Air – Truck
- Truck – Water

Annual logistic costs calculated for all available mode-paths for each firm pair.

The least cost mode-path selected for each firm pair.
Sample Model Sequence #1

Mode: Air, Rail

Shipment size: >10,000 lbs.
Actual Weight: 20,000 lbs.
Annual Frequency: 6
Probability of delivery occurring on a particular day: 20%

Seller in FAF3 zone 486 325412 (Pharmaceutical preparation manufacturing)

Buyer in Tampa, FL 420000 (Wholesale trade)
Policy Sensitivity

• Changes in land use and economy: spatial distribution of employment and mix of industries
• Changes in transportation supply
  – Major highway network changes
  – Changes to rail capacity
  – Intermodal facility capacity changes, including deep water ports and airports
• Changes in distribution center network
  – New facilities (with regional significance)
• Changes in commodity flow origins and destinations outside Florida
Statewide model is designed to be integrated with regional models.

Statewide model develops shipment paths including transfer locations and modes, and intercity truck movements.

Statewide model outputs include a list of regional shipment pick-ups and deliveries that must be met in a given day: that can then be microsimulated in the regional model.

Possible modes of operation:
- Integrate complete statewide model with regional model and run models sequentially.
- Provide an extract from the statewide model of regional shipment demand and run the regional model separately.
Regional Model Framework

- Shipment Flows (from Statewide Model)
- Vehicle and Tour Pattern Choice
- Number of Tours and Stops in each Tour
- Stop Sequence and Stop Duration
- Tour Start Time and output of Trip List
• Implemented in Chicago region for CMAP as part of FHWA project
• Model links shipment deliveries and pick-ups together into truck tours
• Tours built for different truck types and for different patterns: single stop, single loops, several returns to warehouse
• Output is a trip schedule similar to that from an activity-based model of personal travel
Regional Policy Sensitivity

- Regional model input is the output from the statewide model, so statewide model’s sensitivity feeds through to regional model.

- Local (more detailed) distribution of employment and land use affects local truck travel patterns.

- Local changes in transportation supply, non-truck traffic growth causing congestion, and resulting truck travel times.

- Local policies such as truck routes, truck prohibitions, delivery windows, and size limits can be modeled.
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Questions?