Overview of Urban and Intercity Freight Forecasting Models in the US

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Urban Truck Models

- Most urban freight models follow, in principle, the Quick Response Freight Manual. See NCHRP Synthesis #384.
- QRFM is three steps
  - Generation and mode split are combined
    - Gets origins and destinations by zone and by truck type
  - Distribution by gravity model
  - Assignment by whatever procedure makes sense (AON, equilibrium, multiclass, PCEs, etc.)
# Generation/Mode Split

<table>
<thead>
<tr>
<th>Generator</th>
<th>Four-Tire Vehicles</th>
<th>Single Unit Trucks (6+ Tires)</th>
<th>Combinations</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment: *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture, Mining and Construction</td>
<td>1.110</td>
<td>0.289</td>
<td>0.174</td>
<td>1.573</td>
</tr>
<tr>
<td>Manufacturing, Transportation, Communications, Utilities and Wholesale Trade</td>
<td>0.938</td>
<td>0.242</td>
<td>0.104</td>
<td>1.284</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>0.888</td>
<td>0.253</td>
<td>0.065</td>
<td>1.206</td>
</tr>
<tr>
<td>Office and Services</td>
<td>0.437</td>
<td>0.068</td>
<td>0.009</td>
<td>0.514</td>
</tr>
<tr>
<td>Households</td>
<td>0.251</td>
<td>0.099</td>
<td>0.038</td>
<td>0.388</td>
</tr>
</tbody>
</table>
Intercity Models

- NCHRP Project 8-43 (NCHRP Report #606, NCHRP Synthesis #358)
  - Reviewed from late 70’s forward
- Major Model Categories
  - Truck Only
  - OD Table Factoring and Assignment
  - Guidebook on Statewide Travel Forecasting
  - Economic Activity Modeling
- Future Directions
OD Table Factoring and Assignment

- Used for FAF, I-10 and many states
- Usually county-to-county
- Principal data source originally was Reebie (now Global Insight), with many corrections. FAF² is based on the CFS.
- Fratar factor row and columns with employment ratios
- Assignment usually all-or-nothing (FAF used stochastic user-equilibrium for trucks)
IO Analysis

- Part of an old IO Table from MI

<table>
<thead>
<tr>
<th>Commodity Group</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Non-Manuf</th>
<th>HH’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Chemicals</td>
<td>48500</td>
<td>18261</td>
<td>11024</td>
<td>2351</td>
<td>76398</td>
<td>318561</td>
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<tr>
<td>4 Rubber &amp; Plastics</td>
<td>6919</td>
<td>23183</td>
<td>8740</td>
<td>12226</td>
<td>23057</td>
<td>11824</td>
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<tr>
<td>5 Wood Products</td>
<td>4056</td>
<td>2821</td>
<td>88721</td>
<td>1064</td>
<td>66861</td>
<td>75532</td>
</tr>
<tr>
<td>6 Textiles</td>
<td>86</td>
<td>1870</td>
<td>3655</td>
<td>47109</td>
<td>6421</td>
<td>89649</td>
</tr>
</tbody>
</table>
Guidebook on Statewide Travel Forecasting I (also the QRFM II)

- Obtain freight modal networks
- Develop commodity groups (SCTG)
  - SCTG: Standard classification of transported goods
- Relate commodity groups to industrial sectors or economic indicators (NAICS)
  - NAICS: North American Industry Classification System
- Find base-year commodity flows (tons)
- Forecast growth in industrial sectors
- Factor commodity flows (P, C, whole table)
Sixteen Tons

Some people say a man is made outta mud
A poor man's made outta muscle and blood
Muscle and blood and skin and bones
A mind that's a-weak and a back that's strong
You load sixteen tons, what do you get?
Another day older and deeper in debt
Saint Peter don't you call me 'cause I can't go
I owe my soul to the company store…

Merle Travis 1947
Develop modal costs for commodities (if cost sensitivity is needed in the model)

Split commodities to modes
- Models
- Tables
- Expert opinion

Find vehicles from load weights, days of operation

Assign vehicles to modal networks
Now this here's the story about the Rock Island Line. The Rock Island Line she runs down into New Orleans. And just outside of New Orleans is a big toll gate. And all the trains that go through the toll gate They gotta pay the man some money. But of course, if you got certain things on board You're okay and you don't have to pay the man nothin. And just now we see a change comin down the line When you come up to the toll gate The driver, he shout down to the man I got pigs, I got horses, I got cows I got sheep, I got all livestock, I got all livestock I got all livestock. The man say, you alright boy just Get on through, you don't have to pay me nothin. And then the train go through And when he go through the tollgate The train gotta have a little bit of steam And a little bit of speed And when the driver think he safely on the other side He shouts back down the line to the man I fooled you, I fooled you I got pig iron, I got pig iron I got all pig iron, Now I'll tell you where I'm goin boy.

CHORUS: Down the rock island line is a might good road Oh the rock island line is the road to ride The rock island line is a mighty good road Well if you want to ride you gotta ride it like you find it Get your ticket at the station of the rock island line
Critique of Guidebook

- No logistics
  - No tours
  - Shippers and carriers not distinguished
- No intermodal
- Fixed amounts: tons/worker, workers/dollar, volume/ton
- Assignments are coarse
- Economic activity is exogenous
Economic Activity Approach: Oregon

Ohio is similar
Treatment of Space I

State of Oregon

State of Washington

State of California

Pacific Ocean

50 miles
Treatment of Space II
<table>
<thead>
<tr>
<th>TRANSPORT FLOWS (Z-Z)</th>
<th>Industries</th>
<th>Households</th>
<th>MIES</th>
<th>MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport Categories</td>
<td>AGFF</td>
<td>CONS</td>
<td>OMFG</td>
<td>WOOD</td>
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<tr>
<td>CmuteLo</td>
<td>1</td>
<td></td>
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<tr>
<td>CmuteMid</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>CmuteHi</td>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td>Recreation</td>
<td>4</td>
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<tr>
<td>HBobother</td>
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<td>5</td>
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<tr>
<td>NHBobother</td>
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<td>NHBWork</td>
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<tr>
<td>VisitorBus</td>
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<td>VisitorOth</td>
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<tr>
<td>Freight</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>
Spatial Allocation Utility Function Components

\[ U_{ij}^n = \lambda^n (p_j^n + h_j^n) + t_{ij}^n \]

- Commodity Price
- Shadow Price
- Transportation Costs
- Coefficient to control relative importance of price to transportation costs
Market Mechanisms

buying allocation process

exchange zone

commodity flows

exchange zone

selling allocation process

total production

total production

total production
Stepped Each Year, Tends toward Equilibrium

- Distribution of production activity among zones
- Consumption of space by these production activities
- Flows of goods and services and labor from the location (zone) of production to the location (zone) of consumption
- Exchange prices for goods and services, labor and space
Network Level Truck Movements: Microsimulation

- Quasi-equilibrium
- Synthesized individual truck movements
- Vehicle classes: light single-unit, heavy single-unit, articulated
- Shipment characteristics: starting link, ending link, starting time, commodity carried and trans-shipment pattern
- Shipment sizes consistent CFS; value to weight ratio
- Each shipments by commodity, then a tour
- Empties
Supernetwork Mode Split

- Frank-Wolfe decomposition
- Mode alternatives
  - 2-axle truck
  - 3+ axle truck
  - Rail
  - Auto
  - Van
  - Water
  - Air cargo
Critique of Oregon Model

- Extremely Ambitious
  - Development still in process
  - Serious calibration issues
  - “Land use models don’t work” at urban scale so why should they work at statewide scale?
  - Sketchy rail, air cargo
  - Cumbersome
  - Black box problems (not intuitive)
More Critique of Oregon Model

- Computationally messy
  - Kitchen sink
  - Mathematical properties unknown
- Many assumptions still necessary
  - Assumptions well buried
  - Principle of the constant wince factor
- Many Weakness of the Guidebook Still Not Corrected
What’s Next

- Better understanding of transportation costs
  - Cost models for planning
- Better understanding of modal operations
- Behaviorally-based intermodal assignment, transshipment and tours
- Tightly integrated, consistent model structures
- Clear policy objectives
Microsimulation of Freight Flows

- CFIRE initiative to better understand commodity flow in the Mississippi Valley.
- Few selected commodities (corn, automotive components, etc.)
- Microsimulation allows combining databases, e.g.,:
  - FAF²
  - Dun & Bradstreet Establishments
  - County Business Patterns
  - Census of Agriculture
  - Oak Ridge National Highway Network
  - CFS
  - VIUS
Wreck of the Edmund Fitzgerald

The legend lives on from the Chippewa on down
Of the big lake they called 'Gitche Gumee'
The lake, it is said, never gives up her dead
When the skies of November turn gloomy
With a load of iron ore twenty-six thousand tons more
Than the Edmund Fitzgerald weighed empty.
That good ship and true was a bone to be chewed
When the gales of November came early.

Gordon Lightfoot
Microsimulation Idea

- Synthetic farms, but real establishments for processed or manufactured goods
- Random shipments from establishments to random destinations (other establishments) at random times of day. Some establishments may be transshipment points (e.g., intermodal facilities, warehouses and truck terminals).
- Shipments are of random size and will be shipped in random trucks, both TL and LTL.
- Routing will be deterministic, likely dynamic.
Acknowledgements

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