SCAN OF EUROPEAN PRACTICE WITH NATIONAL/STATEWIDE MODELS

Subhro Mitra, PhD
Associate Research Fellow
Faculty – Transportation and Logistics
Upper Great Plains Transportation Institute
North Dakota State University
STATEWIDE FREIGHT PLANNING VARY FROM STATE TO STATE.

States have addressed the issue of freight planning differently, based on their unique needs and budgets.

Unique needs:

- Traffic management studies
- Infrastructure need and investment planning
- Freight logistics supply chain planning
- Warehouse or break-bulk location study
- Forecasting truck traffic for pavement design and development impacts
MANUALS AND REPORTS ON FREIGHT PLANNING

- Application of Statewide Freight-Forecasting Technique
- Quick Response Freight Manual
- Guidebook on Statewide Travel Forecasting
PREVIOUS STATEWIDE FREIGHT-PLANNING PROJECTS

- Wisconsin Freight Model
- Iowa Statewide Truck Flow Model
- Nebraska Intermodal Travel Forecasting Model
- Commodity Flow Modeling for the State of Indiana
- Statewide Freight Flow Distribution for Virginia
- Kansas Agricultural Freight-Flow Model
NORTH DAKOTA STATEWIDE FREIGHT MODEL

- Statewide Freight flow model
  - Agricultural Goods Flow model
    - Internal-Internal
      - Trip Generation
      - Trip Distribution
      - Trip Assignment
    - Internal-External
      - Trip Generation
      - Trip Distribution
      - Trip Assignment
  - Manufactured Goods flow model
    - Internal-External & Internal-Internal
      - Trip Generation
      - Trip Distribution
      - Trip Assignment
    - External-External
      - Trip Generation
      - Trip Distribution
      - Trip Assignment
Highway network for four different phases

Phase 1- March
Phase 2- April
Phase 3- May
Phase 4- rest of the Year
USE OF THE ONION MODEL
AGRICULTURAL FREIGHT MODEL

- Satellite Imagery of Crop Layer
  - GIS Spatial analysis
    - Trip Generation Data

- Grain Movement Database
  - Extract Annual Truck Movement Data
    - Trip Attraction Data

- GIS Network from NDDOT's hub
  - Extract State Network, add Link Attributes and TAZ development
    - Statewide Highway network

- Trip Distribution using Gravity Model
  - OD Data

- Farm Truck Configuration
  - OD Truck Trips
  - Traffic assignment
ANALYZING THE SATELLITE IMAGERY
Raster Layer of Spring Wheat extracted from the Crop Layer
Individual Crop coverage for all 71529 PLSS section polygons are estimated.
METHODOLOGICAL FRAMEWORK OF THE MANUFACTURERS’ FREIGHT MODEL
# List of Major Commodities Moving Out of North Dakota

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Commodity</th>
<th>Quantity in Kton</th>
<th>Percentage of Total</th>
<th>SCTG Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cereal grains</td>
<td>47,011.9</td>
<td>54.0%</td>
<td>02</td>
</tr>
<tr>
<td>2</td>
<td>Coal</td>
<td>51,38.1</td>
<td>5.9%</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Waste/scrap</td>
<td>4,881.0</td>
<td>5.6%</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>Other ag prods.</td>
<td>4,477.8</td>
<td>5.1%</td>
<td>03</td>
</tr>
<tr>
<td>5</td>
<td>Gravel</td>
<td>4,317.6</td>
<td>5.0%</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>Gasoline</td>
<td>3,847.6</td>
<td>4.4%</td>
<td>17</td>
</tr>
<tr>
<td>7</td>
<td>Nonmetal min. prods.</td>
<td>3,242.4</td>
<td>3.7%</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>Fuel oils</td>
<td>2,362.5</td>
<td>2.7%</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>Coal, n.e.c.</td>
<td>1,733.2</td>
<td>2.0%</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>Other foodstuffs</td>
<td>1,638.8</td>
<td>1.9%</td>
<td>07</td>
</tr>
<tr>
<td>11</td>
<td>Unknown</td>
<td>1,471.0</td>
<td>1.7%</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Animal feed</td>
<td>843.3</td>
<td>1.0%</td>
<td>04</td>
</tr>
<tr>
<td>13</td>
<td>Machinery</td>
<td>790.3</td>
<td>0.9%</td>
<td>34</td>
</tr>
<tr>
<td>14</td>
<td>Milled grain prods.</td>
<td>578.9</td>
<td>0.7%</td>
<td>06</td>
</tr>
<tr>
<td>15</td>
<td>Natural sands</td>
<td>562.0</td>
<td>0.6%</td>
<td>11</td>
</tr>
<tr>
<td>16</td>
<td>Mixed freight</td>
<td>557.0</td>
<td>0.6%</td>
<td>43</td>
</tr>
<tr>
<td>17</td>
<td>Wood prods.</td>
<td>547.5</td>
<td>0.6%</td>
<td>26</td>
</tr>
<tr>
<td>18</td>
<td>Live animals/fish</td>
<td>417.6</td>
<td>0.5%</td>
<td>01</td>
</tr>
</tbody>
</table>
**BRIDGE DATA FOR LINKING SCTG WITH NAICS**

$$t_{cj}^a = t_{j}^a \times \sum e_c^b / \sum e^b \quad \forall j$$

<table>
<thead>
<tr>
<th>SCTG Code</th>
<th>NAICS</th>
<th>NAICS S 11</th>
<th>NAICS S 21</th>
<th>NAICS S 23</th>
<th>NAICS S 31</th>
<th>NAICS S 32</th>
<th>NAICS3 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>111, 311</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>212, 324</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>41</td>
<td>324, 331, 313, 327, 112, 111, 333</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>03</td>
<td>111, 311, 325, 313</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>212</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>324, 211</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>31</td>
<td>327, 313, 324, 212, 235, 332, 333, 339, 335</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>211, 324, 325, 212</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>07</td>
<td>311, 312, 313, 319, 111, 325</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>04</td>
<td>113</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>34</td>
<td>333, 335, 332, 314, 322, 331, 336, 339, 334</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>06</td>
<td>111, 311, 325</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>213</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>26</td>
<td>113, 321, 325</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>01</td>
<td>112</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
BENCHMARK INPUT OUTPUT ACCOUNTS - COMMODITY BY INDUSTRY (IN MILLIONS OF DOLLAR VALUE)

<table>
<thead>
<tr>
<th>U_{ij}</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50140</td>
<td>1853</td>
<td>0</td>
<td>1121</td>
<td>0</td>
<td>119307</td>
<td>2872</td>
<td>3689</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>10915</td>
<td>12031</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>2677</td>
<td>0</td>
<td>3</td>
<td>33</td>
<td>14619</td>
</tr>
<tr>
<td>3</td>
<td>366</td>
<td>4</td>
<td>19461</td>
<td>4281</td>
<td>0</td>
<td>123</td>
<td>14</td>
<td>31</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>741</td>
<td>381</td>
<td>29</td>
<td>832</td>
<td>3</td>
<td>709</td>
<td>13</td>
<td>217</td>
<td>80</td>
<td>121</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>148</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>18453</td>
<td>212</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>76318</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3922</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>344</td>
<td>426</td>
<td>19</td>
<td>1143</td>
<td>0</td>
<td>149</td>
<td>3</td>
<td>21018</td>
<td>19185</td>
<td>314</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>380</td>
<td>6202</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>642</td>
<td>29</td>
<td>93</td>
<td>23844</td>
<td>61</td>
<td>426</td>
<td>2</td>
<td>111</td>
<td>13</td>
<td>21425</td>
</tr>
</tbody>
</table>
DISAGGREGATING METHODOLOGY CONT.

\[ \beta_{state} = \beta.(diag L_{state}) \quad \gamma = \beta_{state}.1 \]

\[ C = diag \{ \gamma \}^{-1} \beta_{state} \quad C = \text{adjusted commodity by industry supply side I-O model} \]

\[ D = C.C_e \quad C_e = \text{county employment matrix} \]

\[ D_{ik} = \sum_j C_{ij} \times C_{jk} \quad \text{(Co- ordinate form)} \]

\[ D_{ik} = \text{portion of commodity } i \text{ moving to county } k \]

\[ C_{jk} = \text{employment/population in industry/end-user } j \text{ in county } k \]

\[ C_{ij} = \text{amount of commodity } i \text{ consumed by industry } j \]
\[ \hat{D} = \text{diag}\{D \cdot 1\}^{-1} D \]

\[ \hat{D} = \text{adjusted D matrix making the row sum equal to one.} \]

\[ B_{ikl} = F_{li} \hat{D}_{ik} \]

\[ B_{ijl} = \text{Commodity } i \text{ moving from FAF zone } l \text{ to county } j \]

\[ F_{li} = \text{total Commodity } i \text{ moving into the state from origin } l. \]

\[ i = \text{commodity type, } k = \text{county and } l = \text{origin} \]
NETWORK FOR EXTERNAL – EXTERNAL FLOW
**MATRIX ESTIMATION METHOD**

\[ T_{ij} = a_i b_j t_{ij} \prod_{k} X_k^{R_{ijk}} \]

- \( T_{ij} \): trips from \( i \) to \( j \) in the output matrix
- \( t_{ij} \): observed trips between \( i \) and \( j \).
- \( R_{ijk} \): probability of trip between \( i \) and \( j \) using screenline site \( k \)
- \( a_i, b_j \): model parameters
- \( X_k \): Counts in screenline site \( k \)
TEST NETWORK FOR MATRIX ESTIMATION

**METHOD**

\[
O = \begin{pmatrix}
0 & 5 & 10 & 15 & 20 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 1 & 1 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 \\
\end{pmatrix}
\]
TEST NETWORK WITH TRAFFIC COUNTS

\[
E = \begin{pmatrix}
0 & 0.07 & 0.12 & 49.57 & 0.24 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 5.93 & 1087 & 0 & 20.76 \\
0 & 0 & 0 & 0 & 0 \\
\end{pmatrix}
\]
MEASURE OF GOODNESS OF FIT

\[
\%RMSE = \left( \frac{\sum (Model_j - Count_j)^2}{\sum Count_j / \text{Number of Counts}} \right)^{0.5} \times 100
\]

Percent Root Mean Square

<table>
<thead>
<tr>
<th>Range</th>
<th>% RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 50,000</td>
<td>1.47</td>
</tr>
<tr>
<td>50,000 – 100,000</td>
<td>1.36</td>
</tr>
<tr>
<td>100,000 - 150,000</td>
<td>1.47</td>
</tr>
<tr>
<td>150,000-200,000</td>
<td>9.04</td>
</tr>
<tr>
<td>200,000 - 250,000</td>
<td>8.99</td>
</tr>
<tr>
<td>250,000 – 300,000</td>
<td>1.42</td>
</tr>
<tr>
<td>300,000 - 350,000</td>
<td>.86</td>
</tr>
<tr>
<td>&gt; 350,000</td>
<td>3.30</td>
</tr>
</tbody>
</table>
COMPONENTS OF EUROPEAN MODEL

- Overall modeling framework
- Forecasting trade pattern and the volume of freight
- Initial Production and Consumption Matrix
- Updating the production to Consumption Matrix
- Distribution and Handling factor
- Modal split
- Transportation to vehicle
- Assignment to the modal network

Source: Review of freight Modeling, ME&P
REDEFINE

(Relevance between demand for Freight-Transport and Industry Effects)

Source: Netherlands Economic Institute et al., (1999).
COMPONENTS OF FREIGHT MODEL

- Forecasting trade Pattern
  - Economy, Industry, Political, Technology, Social, Climatic

- Value to volume conversion
  - Changes with time

- Initial P/C matrix
  - Changes outside the transportation and distribution sector
OTHER COMPONENTS OF FREIGHT MODEL

- Updating the production to consumption zone matrix
- O/D matrix from the P/C matrix
- Cost function and supply characteristics
- Modal split and assignment to network
INTERNATIONAL FREIGHT MODELS

- STREAMS / SCENE - multimodal network, reference forecast, modeling software.
  - SLAM (Spatial Logistics Appended Module)

- NEAC MODEL - forecasts of passenger and freight transport for the EU

- STEMM (Strategic European Multimodal Modeling) – European Commission Fourth Framework Program
TRANSPORT CHAINS IN NEAC

Source: Review of freight Modeling, ME&P
INTERNATIONAL MODELS

- ASTRA - Assessment of Transport Strategies
- Fehmarnbelt Model
- Transalpine Model
- Brenner Model
EUROPEAN NATIONAL MODELS

- Dutch National Model (LMS)
  - TEM – II model – (for freight forecasting)
  - QBLOK (for assignment)

- SAMGODS
  - ISMOD Computable General Equilibrium (CGE) model (for freight demand)
  - STAN(for mode and route choice)
EUROPEAN MODELS

- Norwegian model – NEMO
  - STAN
  - REGARD

- Belgian Model, WFTM (Walloon Freight Transport Model)

- ITALIAN MODEL - SISD
EUROPEAN NATIONAL MODELS

- MOBILEC – Netherlands
- TEM – II - Netherlands
- SMILE – Netherlands
SMILE SIMULATIVE MODEL APPROACH

repeat for t years

production chains, regionalisation, maximum entropy model

OD tables for trade

warehouse location, assignment of inventory chains

OD tables for transport

multimodal assignment to network

freight flows and transport costs

PRODUCTION PHASE

INVENTORY PHASE

ASSIGNMENT PHASE

Source: Review of freight Modeling, ME&P
DC Choice mechanisms

\[ G_{rskmnqhz} = O_{kq} + T_{rskqhz} + D_k + Y_{rskhz} + I_{kq} + K_{kq} + Z_{rskq} \]

G: total annual logistics costs
O: order costs
T: transport, consolidation and distribution costs
D: cost of deterioration and damage during transit
Y: capital costs of goods during transit
I: inventory costs (storage costs)
K: capital costs of inventory
Z: stockout costs

Source: Mark Bovenkerk et al.
CONCLUSION

- NEMO and SAMGODS and most national and regional freight model lack logistics aspects
- SMILE – Netherlands, Portland – Oregon has logistics aspects

Steps of logistics model
- Disaggregate - PWC flows to individual firms
- Models for logistics decision by the firms
- Aggregate shipment to OD for assignment
DISCUSSION