Choosing the Right Model: Effects of Economic Model Selection Truck-Freight Network Investment Prioritization

Freight Policy Transportation Institute
Jeremy Sage, PhD, Washington State University
Kenneth Casavant, PhD, Washington State University
A Framework for Determining Highway Truck-Freight Benefits and Economic Impacts

Zun Wang, University of Washington
Jeremy Sage, Washington State University
Anne Goodchild, University of Washington
Eric Jessup, Albert-Ludwigs-Universität
Kenneth Casavant, Washington State University
Rachel L. Knutson, Washington State Department of Transportation
The Washington State Freight Mobility Plan

Goal:

Develop and **prioritize** freight transportation system improvement strategies that support and enhance trade and sustainable economic growth, safety, the environment, and goods delivery needs in the state.

Make a strong case for funding Washington state’s freight priority projects in the reauthorization of the federal transportation bill and freight programs, and future state transportation packages.

Guide capital and operating investments in the state’s freight systems.
Background

• To prioritize, it must be recognized.

• Fully evaluate the truck-freight benefits.
  • Direct benefits
  • Indirect benefits
Research Objectives

- Propose a transparent methodology for calculating both the direct freight benefits and the larger economic impacts of freight projects.

- Apply the methodology for projects assessment.
Methodology

- Identify Benefits
  - Literature review
  - WSDOT current project prioritization process
  - Three technical groups (urban goods movement, global gateway, and rural economies)
Identifying the Beneficiaries of Network Improvement

- **Carriers**: Travel Time; Reliability; Accessibility; Safety
- **Shippers**: Where carriers experience efficiency gains, shippers may configure long run changes to their scale, scheduling and overall logistics.
- **Industries and Markets**: The freight recipients may be able to adjust market production patterns as well as distribution and supply regions.
- **Non-Freight Impacts: Economic Development**: As business productivity (shipper, carrier, and recipient) is enabled, changes to activity patterns impacting job creation are enhanced.
  - Necessitates the implementation of Economic Impact Models.
Methodology

- **Direct Freight Benefits:**
  - Truck travel time savings
  - Truck operating cost savings
  - Truck emission changes

- **Economic Impacts:**
  - Employment changes
  - Regional economic output changes
Methodology

**INPUTS**

- Project Specific Data Inputs
- Travel Demand Model
- Modeling Transportation Related Benefits

**FRAMEWORKS**

- Modeling Economic Impacts Using:
  - Washington State CGE or I-O

**OUTPUTS**

- Benefits from:
  - Travel Time Savings
  - Operating Cost Savings
  - Emissions Changes
- Employment Changes
- Regional Economic Output

CGE: computable general equilibrium model
I-O: Input-Output Model
**Objective:** Develop statistical models to represent the flow of dollars between industries has been used to relate transportation investments to productivity and employment.

- **Input–Output (I–O) Models**
  - Fixed Priced Model – Partial Equilibrium
  - Frequently (and easily?) used by policy analysts
  - Is a fixed price assumption reasonable for this type of shock?
    - Production Technology Improvement
  - Backwards Linkages
    - Where to apply the shock?
Methodology--Economic Impacts Analysis (EIA) -- Data

- Utilizes Social Accounting Matrices (SAM) from the 2010 IMPLAN data.
- Aggregate into 20 industrial Sectors:

<table>
<thead>
<tr>
<th>Aggregation Code</th>
<th>Freight Dependent Industries</th>
<th>Aggregation Code</th>
<th>Other Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGFOR</td>
<td>Agriculture and Forestry</td>
<td>INFO</td>
<td>Information Services</td>
</tr>
<tr>
<td>MIN</td>
<td>Mining</td>
<td>FININS</td>
<td>Financial and Insurance</td>
</tr>
<tr>
<td>UTIL</td>
<td>Utilities</td>
<td>REAL</td>
<td>Real Estate</td>
</tr>
<tr>
<td>CONST</td>
<td>Construction</td>
<td>PROTEC</td>
<td>Professional and Technical</td>
</tr>
<tr>
<td>MANUF</td>
<td>Manufacturing</td>
<td>MANAG</td>
<td>Management</td>
</tr>
<tr>
<td>WTRAD</td>
<td>Wholesale Trade</td>
<td>ADMIN</td>
<td>Administration</td>
</tr>
<tr>
<td>RTRAD</td>
<td>Retail Trade</td>
<td>SOCSER</td>
<td>Social Services</td>
</tr>
<tr>
<td>TRAWAR</td>
<td>Transportation and Warehousing</td>
<td>ARTS</td>
<td>Arts and Entertainment</td>
</tr>
<tr>
<td>TRUCK</td>
<td>Transport by Truck</td>
<td>FOOD</td>
<td>Food Services</td>
</tr>
<tr>
<td>WMAN</td>
<td>Waste Management</td>
<td>OTHHR</td>
<td>Other (Including Government)</td>
</tr>
</tbody>
</table>
Methodology--Economic Impacts Analysis (EIA) – Model

**Objective:** Develop statistical models to represent the flow of dollars between industries has been used to relate transportation investments to productivity and employment.

- **Computable General Equilibrium (CGE) Models**
  - Market Clearing Prices and Quantities.
  - Allows flexibility in price
  - Firm Production: Household Inputs: Intermediate or Final Consumption
  - However, significantly more difficult to operate...correctly.
  - Initiating the shock
Methodology--Economic Impacts Analysis (EIA) – I-O Model

- Carrier benefits => increased productivity => reduced costs to freight dependent businesses => output increase.

\[ D_{1i} = D_{0i} \left( \frac{X_{1i}}{X_{0i}} \right)^e , \]

- \( D_{0i} \) = Output before Infrastructure Investment for Industrial Sector i (IMPLAN generated)
- \( D_{1i} \) = Output after Infrastructure Investment for Industrial Sector i
- \( X_{0i} \) = Cost of Production attributable to trucking before Infrastructure Investment for Industrial Sector i
- \( X_{1i} \) = Cost of Production attributable to trucking after Infrastructure Investment for Industrial Sector i
- \( e \) = Elasticity of output with respect to production cost
Methodology--Economic Impacts Analysis (EIA) – CGE Model

• Create four regional CGE models.
  • 2 Geographic scales
  • Long-Run (LR) and Short-Run (SR) scenarios

• Model the infrastructure investment as an improvement in technology.
  • Improves the productivity of the transportation system
  • Initiate the CGE through a counterfactual that shifts the industry supply curve: (Cobb-Douglas shown for simplicity)

\[ Q = S(K^\alpha L^{1-\alpha}) \]

• Value of the shift is dependent upon the percent change in operating costs to the trucking industry
Case Study

- Interstate-highway widening project
  - 10 mile, 2 lanes each direction.
  - A critical connector for the region and serves approximately 9,000 trucks daily.
  - Freight demand is projected to increase by 30% over the next 10 years.
  - Adding one lane each direction.
## Case Study -- Economic Impacts

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Demand Model Benefit Output</td>
<td>$4,533,563</td>
</tr>
<tr>
<td>Spokane County Intermediate Expenditures (TRUCK)</td>
<td>$139,875,763</td>
</tr>
<tr>
<td>Statewide Intermediate Expenditures (TRUCK)</td>
<td>$1,760,368,000</td>
</tr>
<tr>
<td>Change in Truck Transport Productivity - Spokane County</td>
<td>3.24%</td>
</tr>
<tr>
<td>Change in Truck Transport Productivity - State</td>
<td>0.26%</td>
</tr>
</tbody>
</table>
## Case Study -- Economic Impacts

<table>
<thead>
<tr>
<th>Model</th>
<th>Employment</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statewide Model</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR-CGE</td>
<td>47.3</td>
<td>$22,241,506</td>
</tr>
<tr>
<td>I-O</td>
<td>81.5</td>
<td>$13,272,773</td>
</tr>
<tr>
<td><strong>Spokane County Model</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR-CGE</td>
<td>78.0</td>
<td>$28,675,616</td>
</tr>
<tr>
<td>I-O</td>
<td>65.5</td>
<td>$8,071,935</td>
</tr>
</tbody>
</table>

- CGE Output > I-O Output
- Employment?
## Case Study -- Economic Impacts

### County

<table>
<thead>
<tr>
<th>Sector</th>
<th>Employment Change LR-CGE</th>
<th>I-O</th>
<th>Output Change LR-CGE</th>
<th>I-O</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANUF</td>
<td>45.8</td>
<td>5.6</td>
<td>$13,676,449</td>
<td>$1,732,818</td>
</tr>
<tr>
<td>TRAWAR</td>
<td>-2.6</td>
<td>1.2</td>
<td>$125,054</td>
<td>$148,070</td>
</tr>
<tr>
<td>TRUCK</td>
<td>-38.0</td>
<td>4.1</td>
<td>$(179,227)</td>
<td>$463,447</td>
</tr>
<tr>
<td>Total</td>
<td>78.0</td>
<td>65.5</td>
<td>$28,675,616</td>
<td>$8,071,935</td>
</tr>
</tbody>
</table>

### Statewide

<table>
<thead>
<tr>
<th>Sector</th>
<th>Employment Change LR-CGE</th>
<th>I-O</th>
<th>Output Change LR-CGE</th>
<th>I-O</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANUF</td>
<td>27.0</td>
<td>9.9</td>
<td>$11,510,000</td>
<td>$4,668,419</td>
</tr>
<tr>
<td>TRAWAR</td>
<td>-3.2</td>
<td>1.7</td>
<td>$166,450</td>
<td>$264,503</td>
</tr>
<tr>
<td>TRUCK</td>
<td>-32.8</td>
<td>4</td>
<td>$80,113</td>
<td>$479,240</td>
</tr>
<tr>
<td>Total</td>
<td>47.3</td>
<td>81.5</td>
<td>$22,241,506</td>
<td>$13,272,773</td>
</tr>
</tbody>
</table>
**Case Study -- Economic Impacts - CGE**

<table>
<thead>
<tr>
<th>Region</th>
<th>Initial Employment Level</th>
<th>Change in Employment</th>
<th>Change in Activity Quantity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SR</td>
<td>LR</td>
</tr>
<tr>
<td>County</td>
<td>264,128</td>
<td>25.5</td>
<td>77.9</td>
</tr>
<tr>
<td>State</td>
<td>5,647,012</td>
<td>22.4</td>
<td>47.2</td>
</tr>
</tbody>
</table>

- **Price for truck services and regional output sales change:**
  - **County**
    - SR: 1.94% decrease in price and $9.8 million increase in sales
    - LR: 1.67% decrease in price and $28.7 million increase in sales
  - **State**
    - SR: 0.18% decrease in price and $10.5 million increase in sales
    - LR: 0.14% decrease in price and $22.2 million increase in sales
Discussion

- The I-O model results will never produce a negative number when modeling an increase in output by a sector.
- The I-O model does not account for the trucking industry becoming more efficient and able to do more with fewer trucks.
  - Over estimates employment change.
- Output CGE>Output I-O
  - Productivity and flexibility
- Geography Matters
  - Expected region of impact
Limitations and Future Work

- Limitations of using TDMs
- Limited feedback loops between TDM and Impact Models
- Future work
  - Freight performance data
  - Enhancing dynamic nature of models
Conclusion

- A quantitative and transparent methodology capturing freight benefits can be used for freight project impacts assessment and project prioritization.
- Industrial base of a geographical region significantly impacts model outputs.