Measuring Total Economic Benefits of USCG Marine Safety Programs

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CREATE

USC
Objectives of the Study

• Evaluate the benefits of Marine Safety Programs by estimating all potential regional and national economic losses of a port disruption.

• Refine the consequence analysis methodology to factor in various resilience adjustments.

• Estimate the effectiveness of resilience tactics related to port disruptions.
Economic Losses of Port Disruptions

- Direct losses
  - damage to port facilities
  - damage to ships and cargo

- Indirect losses
  - direct business interruption at the port
  - indirect business interruption to the economy
  - environmental damage

\[ \Rightarrow \text{Probability-weighted avoided losses} = \text{benefits of safety programs} \]
Defining Economic Resilience

• **Static**: Ability of a system to maintain function when shocked (efficient use of remaining resources at a given point in time).

• **Dynamic**: Speed of a system to recover from a shock (efficient use of resources over time for investment in repair and reconstruction).
Measuring Econ Resilience of 9/11

- 95% of over 1,100 WTC area firms relocated after 9/11
- If all of firms in the WTC area went out of business, direct business interruption (BI) loss would = $58.4B
- If all relocation were immediate, then no BI
- Businesses relocated within 8 months, BI = $16.1B
- Resilience Metric: Avoided Loss ÷ Max Potential Loss
  $42.3B ÷ $58.4B = 72%
Resilience to Port Disruptions

- Strategic Petroleum Reserve
- Ordinary Inventories of all goods
- Conservation by Customers
- Import Ship Diversion & Overland Rerouting
- Export Diversion (to replace imports)
- Production Rescheduling (Recapture)
Input-Output Analysis Approach

• Definition: A linear model of all purchases and sales between sectors of the economy, based on the technological relations of production.

• Most widely used tool of impact analysis

• Will use two versions:
  - Demand-side (upstream in supply-chain)
  - Supply-side (downstream in supply chain)
Figure 1. Estimating Total Economic Impacts of A Port Shutdown
Port Arthur/Beaumont Case Studies

• Two Scenarios:
  1. Complete Port Shutdown (90 days)
  2. Medium Consequence (4 days)

• Evaluate Impacts for Two Geographic Areas:
  - 3-County Beaumont-Port Arthur MSA
  - U.S. as a whole

• Factor in 6 types of resilience
Port Arthur Economy

• Total Gross Output in 2008: $71 billion
  - Petroleum Refining nearly 50%
  - Petro & Other Chemicals 15%
  - Other sectors (Construction, Business Svcs)

• Imports by ship:
  - More than 60% are Crude Oil
  - Other commodities (Petroleum and Other Chemical Products about 25%)
Resilience to Port Disruptions: Ship Diversion & Overland Rerouting

- USCG estimate: 90% re-routing of import shipping
- Assume no re-routed crude oil and refined petroleum products are transported back to the Port Region
- Direct output losses reduced from $7.0 to $4.5 billion
Resilience: Strategic Petroleum Reserve (SPR)

- Release 4.16 million barrels of crude oil from SPR (= 20% of total SPR drawdown in the aftermath of Hurricane Katrina)

- Major Presidential political decision

- Aim in this case: to maintain minimum level operation of key refineries in the Region

- Direct output losses reduced from $7.0 to $6.5 billion
Resilience: Ordinary Inventories of All Goods

• Use of inventories by port customers to reduce the impact from import disruptions

• Direct output losses reduced from $7.0 to $5.0 billion
Resilience: Export Diversion (to replace imports)

- Diversion of export commodities to importers of the same commodities
- Reduce potential losses on both import and export sides
- Direct output losses reduced from:
  - $7.0 to $6.0 billion on the import side
  - $3.3 to $1.5 billion on the export side
Resilience: Conservation

• More careful use of scarce materials

• Assume the ability to conserve 2% of all material inputs

• Direct output losses reduced from $7.0 to $6.8 billion
Resilience: Production Rescheduling (Recapture)

- Ability to make up lost production through working overtime or extra shifts after the crisis is over

- Often found to be the most effective resilience measure in the literature

- Apply directly to total losses (direct + indirect)
## Summary Table 1. Gross Output Impacts

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Output Impact w/o Resilience</th>
<th>Output Impact w/ Resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million 2008$</td>
<td>Percent</td>
</tr>
<tr>
<td>Medium Consequence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port Region</td>
<td>452.2</td>
<td>57.8%</td>
</tr>
<tr>
<td>U.S.</td>
<td>3,735.6</td>
<td>1.2%</td>
</tr>
<tr>
<td>Complete Port Shutdown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port Region</td>
<td>12,729.4</td>
<td>71.4%</td>
</tr>
<tr>
<td>U.S.</td>
<td>164,903.5</td>
<td>2.4%</td>
</tr>
</tbody>
</table>
## Economic Impacts of the 3-Month Port Arthur/Port Beaumont Import Disruption

(in million 2008 dollars)

<table>
<thead>
<tr>
<th>Case</th>
<th>Direct Output Loss</th>
<th>Total Impacts</th>
<th>Total Impacts (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Base Case (No Resilience)</td>
<td>$6,959</td>
<td>$9,622</td>
<td>(53.9%)</td>
</tr>
<tr>
<td>B. With Ship Re-routing</td>
<td>$4,549</td>
<td>$5,498</td>
<td>-23.1%</td>
</tr>
<tr>
<td>C. With Export Diversion</td>
<td>$5,962</td>
<td>$8,372</td>
<td>-7.0%</td>
</tr>
<tr>
<td>D. With SPR</td>
<td>$6,555</td>
<td>$9,178</td>
<td>-2.4%</td>
</tr>
<tr>
<td>E. With Use of Inventories</td>
<td>$4,958</td>
<td>$6,757</td>
<td>-16.0%</td>
</tr>
<tr>
<td>F. With Conservation</td>
<td>$6,820</td>
<td>$9,475</td>
<td>-0.8%</td>
</tr>
<tr>
<td>G. W/ Production Rescheduling</td>
<td>b</td>
<td>$5,078</td>
<td>-25.4%</td>
</tr>
<tr>
<td>H. With All Resilience Adjusts</td>
<td>c</td>
<td>$2,092</td>
<td>-42.2%</td>
</tr>
</tbody>
</table>
Summary

• Input-Output approach valid for S-R disruptions, if supplemented by resilience adjustments

• 90-day Port Arthur/Beaumont disruption could reduce economic activity in MSA by $13 billion, 71% of GDP (resilience can reduce total losses to $4 billion, 23%)

• 90-day Port Arthur/Beaumont disruption could reduce economic activity in US by $165 billion, 2.4% of GDP (resilience can reduce total losses to < 0.1% of GDP)

• Production rescheduling and re-routing are the two most effective resilience tactics for port disruptions
Future Work

- Apply SOA Computable General Equilibrium Model
- Factor in cost increases of ship diversion
- Factor in input substitution
- Factor in market resilience from price adjustments
### Summary Table 2. Miscellaneous Costs

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost (million 2008$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Costs of Oil Spill</td>
<td>0.7</td>
</tr>
<tr>
<td>Delay Costs of Shipping</td>
<td>4.0</td>
</tr>
<tr>
<td>Security Value of Oil Release from SPR</td>
<td>15.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20.3</strong></td>
</tr>
</tbody>
</table>
## Total Sectoral and Regional Economic Impacts of the Port Disruption

<table>
<thead>
<tr>
<th>#</th>
<th>Sector</th>
<th>Total Output Impacts of Imports, Exports, Port On-Site Operation Disruptions ($M)</th>
<th>After Cap Total Impacts ($M)</th>
<th>% Output Impacts</th>
<th>Total Output Impacts of Imports, Exports, Port On-Site Operation Disruptions (After Resilience Adjs) ($M)</th>
<th>% Output Impacts (After Resilience Adjs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Construction</td>
<td>299.5</td>
<td>299.5</td>
<td>36%</td>
<td>24.3</td>
<td>3%</td>
</tr>
<tr>
<td>17</td>
<td>Petroleum refineries</td>
<td>7,467.3</td>
<td>7,467.3</td>
<td>85%</td>
<td>2,782.1</td>
<td>32%</td>
</tr>
<tr>
<td>20</td>
<td>Petrochemical mfg</td>
<td>2,194.5</td>
<td>1,668.0</td>
<td>100%</td>
<td>313.9</td>
<td>19%</td>
</tr>
<tr>
<td>22</td>
<td>Other basic organic chemical mfg</td>
<td>1,163.9</td>
<td>579.3</td>
<td>100%</td>
<td>350.4</td>
<td>60%</td>
</tr>
<tr>
<td>25</td>
<td>Other chemical mfg</td>
<td>628.3</td>
<td>556.2</td>
<td>100%</td>
<td>81.4</td>
<td>15%</td>
</tr>
<tr>
<td>30</td>
<td>Iron and steel mills and ferroalloy mfg</td>
<td>201.3</td>
<td>180.2</td>
<td>100%</td>
<td>121.3</td>
<td>67%</td>
</tr>
<tr>
<td>33</td>
<td>Other machinery and equipment mfg</td>
<td>226.3</td>
<td>226.3</td>
<td>61%</td>
<td>15.9</td>
<td>4%</td>
</tr>
<tr>
<td>47</td>
<td>Other business services</td>
<td>309.3</td>
<td>309.3</td>
<td>43%</td>
<td>37.3</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>13,933.7</strong></td>
<td><strong>12,729.4</strong></td>
<td><strong>71%</strong></td>
<td><strong>4,021.7</strong></td>
<td><strong>23%</strong></td>
</tr>
</tbody>
</table>