Evaluating the Role of Resilience in Recovering from Major Port Disruptions

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Background

• Ports play a vital role in a nation’s economic well-being.

• An increasing number of port disruptions have taken place in recent years.

• Many studies have estimated the direct and indirect impacts of port disruptions.

• However, very few studies have adequately factored in port resilience in the economic impact analysis.
Objectives of this Study

• Develop a framework for identifying and evaluating the appropriate set of economic resilience options to port disruptions.

• Formally analyze the effects of various resilience measures in a computable general equilibrium model.

• Evaluate the effectiveness of various resilience tactics using a major port disruption case study.
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).
Resilience Tactics

• Supplier-side resilience options:
  – Excess capacity
  – Cargo prioritization
  – Ship re-routing
  – Export diversion for import use
  – Effective management
  – Production recapture (Rescheduling)

• Customer-side resilience options:
  – Inventories
  – Conservation
  – Input Substitution
  – Production recapture (Rescheduling)
Port Valuation

- Standard approach for estimating economic impact of a port: direct econ activity $\times$ multiplier
  - Direct economic activity = Port revenue
  - POLA/POLB: $220$ million $\times 5.9 = $1.3$ billion

- But the standard approach misses the value of the cargo & its contribution to rest of the economy
Results for Port Arthur/Beaumont
(90-day Disruption; Business Interruption Loss)

• Comparison of estimates:
  - Standard estimate: $1.3 billion
  - SOA approach (w/o resilience): $14.8 billion
  - SOA approach (w/ resilience): $4.8 billion

• Supply chain effects increase impacts 10-fold

• Resilience lowers the economic impacts by 67%
  (and at relatively low-cost)
Major Port Disruption Scenario

• Large-Scale Tsunami Scenario (but generalizes across disasters)

• POLA/POLB completely shut down immediately after the disaster event

• Ports recover to their pre-disaster operation levels by end of one year (recovery path is linear)

• Import and Export supply-chains disrupted
Framework of Estimating Total Economic Impacts of a Port Disruption
TERM Model

- Bottom-up multi-regional CGE model
- Based on detailed regional & sectoral accounts
- Consists of 4 regions: 3-County LA Region, 9-County Bay Area, Rest of CA, and Rest of U.S.
- Divides the economy into 97 sectors
- CES production functions (allows for substitution)
- Explicit trade and transport margins
# Modeling Resilience Tactics in TERM Model

<table>
<thead>
<tr>
<th>Tactic</th>
<th>Variable</th>
<th>Representation/notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation</td>
<td>aprim</td>
<td>Technical change parameter of the CES function, by industry and region</td>
</tr>
<tr>
<td>Port Excess capacity</td>
<td>fimps, fqexp</td>
<td>Adjust import and export shocks</td>
</tr>
<tr>
<td>Inherent Input Substitution</td>
<td>n/a</td>
<td>Inherent input substitution ability captured by the model automatically</td>
</tr>
<tr>
<td>Import Substitution</td>
<td>ARMSIGMA</td>
<td>Inherent import substitution ability is captured by the model automatically by the specification of the Armington elasticity of substitution</td>
</tr>
<tr>
<td>Ship Rerouting</td>
<td>fimps, fqexp</td>
<td>Adjust import and export shocks in different regions</td>
</tr>
<tr>
<td>Export Diversion for Import Use</td>
<td>fimps, fqexp</td>
<td>Adjust import and export shocks</td>
</tr>
<tr>
<td>Inventory Use</td>
<td>fimps</td>
<td>Adjust import shock</td>
</tr>
<tr>
<td>Production Recapture</td>
<td>side-calculation</td>
<td>Application of “Recapture Factor Parameter” to adjust the total loss estimate by sector</td>
</tr>
</tbody>
</table>
# Simulation Results

## Real GDP Impact of the Port Disruption Scenario (million 2010$)

<table>
<thead>
<tr>
<th></th>
<th>LA Region</th>
<th>Bay Area</th>
<th>Rest of CA</th>
<th>Rest of US</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case (No Resilience)</td>
<td>-$7,475</td>
<td>-$2,256</td>
<td>-$2,318</td>
<td>-$4,273</td>
<td>-$16,322</td>
</tr>
<tr>
<td>With Ship Rerouting</td>
<td>-$4,343</td>
<td>-$1,184</td>
<td>-$1,284</td>
<td>-$1,160</td>
<td>-$7,971</td>
</tr>
<tr>
<td>With Export Diversion</td>
<td>-$6,548</td>
<td>-$1,833</td>
<td>-$1,952</td>
<td>-$529</td>
<td>-$10,863</td>
</tr>
<tr>
<td>With Use of Inventory</td>
<td>-$7,877</td>
<td>-$2,881</td>
<td>-$2,611</td>
<td>$2,556</td>
<td>-$10,813</td>
</tr>
<tr>
<td>With Production Rescheduling</td>
<td>-$2,599</td>
<td>-$773</td>
<td>-$816</td>
<td>-$1,455</td>
<td>-$5.642</td>
</tr>
<tr>
<td>With All Resilience Adj</td>
<td>-$1,621</td>
<td>-$550</td>
<td>-$533</td>
<td>$982</td>
<td>-$1,722</td>
</tr>
</tbody>
</table>
## Summary of Resilience Potential

### Loss Reduction Potentials of Individual Resilience Tactics

<table>
<thead>
<tr>
<th>Loss Reduction Potential</th>
<th>Potential Percentage Reduction of Total National GDP Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship Rerouting</td>
<td>51.2%</td>
</tr>
<tr>
<td>Export Diversion</td>
<td>33.5%</td>
</tr>
<tr>
<td>Conservation</td>
<td>2.5%</td>
</tr>
<tr>
<td>Use of Inventory</td>
<td>33.8%</td>
</tr>
<tr>
<td>Production Rescheduling</td>
<td>65.4%</td>
</tr>
<tr>
<td>All Resilience Adjustments</td>
<td>89.5%</td>
</tr>
</tbody>
</table>
Policy Recommendations

• Economic impacts of port disruptions are far reaching and require a comprehensive modeling approach.

• Port vulnerability & resilience assessment is a critical step in building resilience capacity to help port and supply-chain managers identify bottlenecks and resilience tactics.

• Most ports are much less resilient to large disruptions; more planning is needed for worst case scenarios.

• More research is needed to optimize resilience tactics.