Development and Application of an Economic Framework to Evaluate Resilience in Recovering from Major Port Disruptions

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Project Objective

Ports play a critical role in a nation's economic system. The impact of a major port disruption can reverberate across the entire economy through regional and national supply-chains. This study develops an operational framework to evaluate the effectiveness of a comprehensive list of potential resilience tactics that can help ports and related businesses in the supply-chain recover more rapidly from port disruptions. The assessment of the various resilience tactics is formally incorporated into the economic consequences analysis. The TERM multi-regional computable general equilibrium (CGE) model is adopted and applied to the assessment of the economic consequences and the effects of various resilience tactics of two port disruption scenarios with different magnitudes and durations.

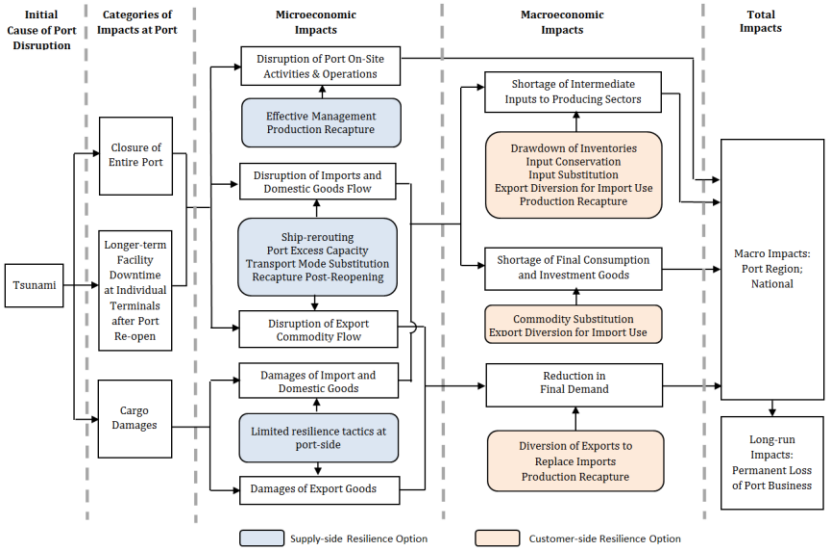
Problem Statement

Ports play a vital role in a nation's economic well-being. They represent the major portal for its material exchanges with the rest of the world and, in some cases, with other regions within its own borders. Because it serves as a critical element of the nation's supply-chain, a disruption of a major port can reverberate throughout the entire economy. Imported inputs for intermediate and final consumption cannot be delivered, thereby causing production interruptions down the supply chain and reductions in economic well-being of the end-users. Also exports for other markets are blocked, thus causing an ensuing disruption of production up the supply chain as domestic producers cancel their orders for inputs. An increasing number of port disruptions have taken place in recent years, caused by such phenomena as natural disasters, technological accidents, and labor disputes. Moreover, ports are a prime target for terrorist attacks, which can be fine-tuned to yield the maximum disruption at the port site and beyond.

Research Methodology

The figure below displays the framework for analyzing total economic impacts of a major port disruption across five time stages. It also indicates relevant supplier-side and customer-side resilience tactics that can be implemented to reduce potential losses from port disruptions. We incorporate the analysis of the various port resilience tactics into a multi-regional CGE model – TERM (The Enormous Regional Model), and apply this model to analyze the total economic impacts of two port disruption scenarios. The effects of the resilience tactics are analyzed in the TERM Model by performing side calculations to adjust the direct impact input data, or through

the adjustments of appropriate parameters and elasticities in the model. The TERM Model consists of 4 regions (Northern California, Southern California, the Rest of California and the Rest of the U.S.) and 97 economic sectors. The direct impacts of port disruptions are calculated based on detailed analysis of import and export disruptions at 4-digit HTS (Harmonized Tariff Schedule) level. Data for the potential of various resilience tactics are gathered from various sources, including the U.S. Geological Survey Tsunami Research Team, port contacts at POLA/POLB, literature review, and publically available data.



Results

The modeling results indicate that without the consideration of port and economic resilience, the lower-bound disruption scenario (the USGS SAFRR Tsunami Scenario that results in a 2-day port shutdown and facility downtimes at only a few terminals up to no more than one month at POLA, POLB, and Port of Oakland) could cause total GDP losses of about $650 million, while the upper-bound disruption scenario (an extreme local tsunami disaster that causes a one-year port disruption at POLA/POLB) could result in GDP losses of over $12 billion in California and $16 billion at the national level. However, resilience can potentially reduce the impacts of the lower-bound disruption scenario by more than 95% and the impacts of the upper-bound disruption scenario by about 75% for California and nearly 90% for the nation as a whole. Our findings suggest that the effects of various resilience tactics to port disruptions vary substantially under threats of different magnitudes. Resilience tactics such as the use of inventories and production rescheduling were found to have particularly strong contributions to the reductions of economic losses in a relatively small disruption event. However, their effects decrease dramatically in large disruption event. On the other hand, the effects of other resilience tactics, such as ship rerouting and export diversion increase considerably as the magnitude of port disruption enlarges.

Loss Reduction Potentials of Individual Resilience Tactics

	Total	
	Lower-Bound Scenario	Upper-Bound Scenario
Excess Capacity	16.6%	N/A
Ship Rerouting	5.3%	51.2%
Export Diversion	9.9%	33.5%
Conservation	0.1%	2.5%
Use of Inventory	82.4%	33.8%
Production Rescheduling	84.3%	65.4%
All Resilience Adjustments*	97.4%	89.5%

* Not equal to sum of entries above due to overlaps among resilience tactics.

Policy Implications

- Economic impacts of port disruptions are far reaching and require a comprehensive modeling approach.
- Port vulnerability and 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.
- High priority should be given to maintaining continuous communication among the various stakeholders in the aftermath of port disasters to expedite the recovery process.