Economic Consequences of and Resilience to a Disruption of Oil Trade: Role of Seaports in U.S. Energy Security

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Terrorist Threats to Seaports

- Terrorist attacks on the rise worldwide
  - most experts view seaports as prime targets; hence their designation as “critical infrastructure”
  - but is every port critical to national/economic security?
- Criticality threshold especially important in U.S
  - many ports to protect; all clamoring for funds
  - protect all incrementally vs. allocate funds to *most* critical
- Criticality depends not only on port size, but also on:
  - key cargoes (e.g., crude oil, refined petroleum)
  - entire supply-chains upstream & downstream offsite

Objectives

1. Refine a methodology for estimating the economic consequences of a seaport disruption
   - direct impacts (on-site)
   - supply-chain impacts (off-site)
   - resilience (both suppliers & customers)
2. Apply to disruption of trade at an average seaport
   - Port Arthur/Beaumont, Texas
   - *focus on crude oil and refined petroleum products*
3. Findings
   - resilience is very strong, especially at national level
   - resilience strongly affected by recent oil shale boom

U.S. Petroleum System

- Current Status:
  - Largest refinery, pipeline & storage system
  - Largest exporter of refined products
- Recent Trends
  - U.S. shale/tight oil production revolution
  - expansion of refineries to process imported heavy crude
  - large expansion of crude pipeline & storage capacity
  - 400% increase in light crude/refined exports since 2006
- Petroleum Admin for Defense District (PADD3)
  - 75% of new light crude feeds into this system
  - 75% of U.S. exports of crude & refined products from here

Port Arthur/Beaumont MSA

- 3 counties in South Texas with TGO (Sales) of $81B
- Refined Petroleum
  - 33% of regional TGO
  - 58% of regional demand satisfied by regional suppliers
  - 93% of regional output exported to RUS and ROW
- Crude Oil Demand
  - 99% of regional demand satisfied by imports
  - 93.4% of demand is for refining; 5.4% for chemicals
- Refined Petroleum contribution to the U.S economy
  - 6.7% of national refined petroleum products
  - 2% of U.S. imports and 10.2% of U.S exports

Methodology: Input-Output Analysis

- Definition: Economy as set of integrated supply chains
- “Old-fashioned” tool (vs. CGE)
- Well-suited to case at hand:
  - requires deliberate examination of supply- & demand-side
  - allows for decomposition of results (up & downstream)
  - transparent base, analysis and results
  - less demanding of economic data
  - shortcomings not an issue (e.g., no input substitution)
  - able to accommodate nearly all relevant resilience tactics

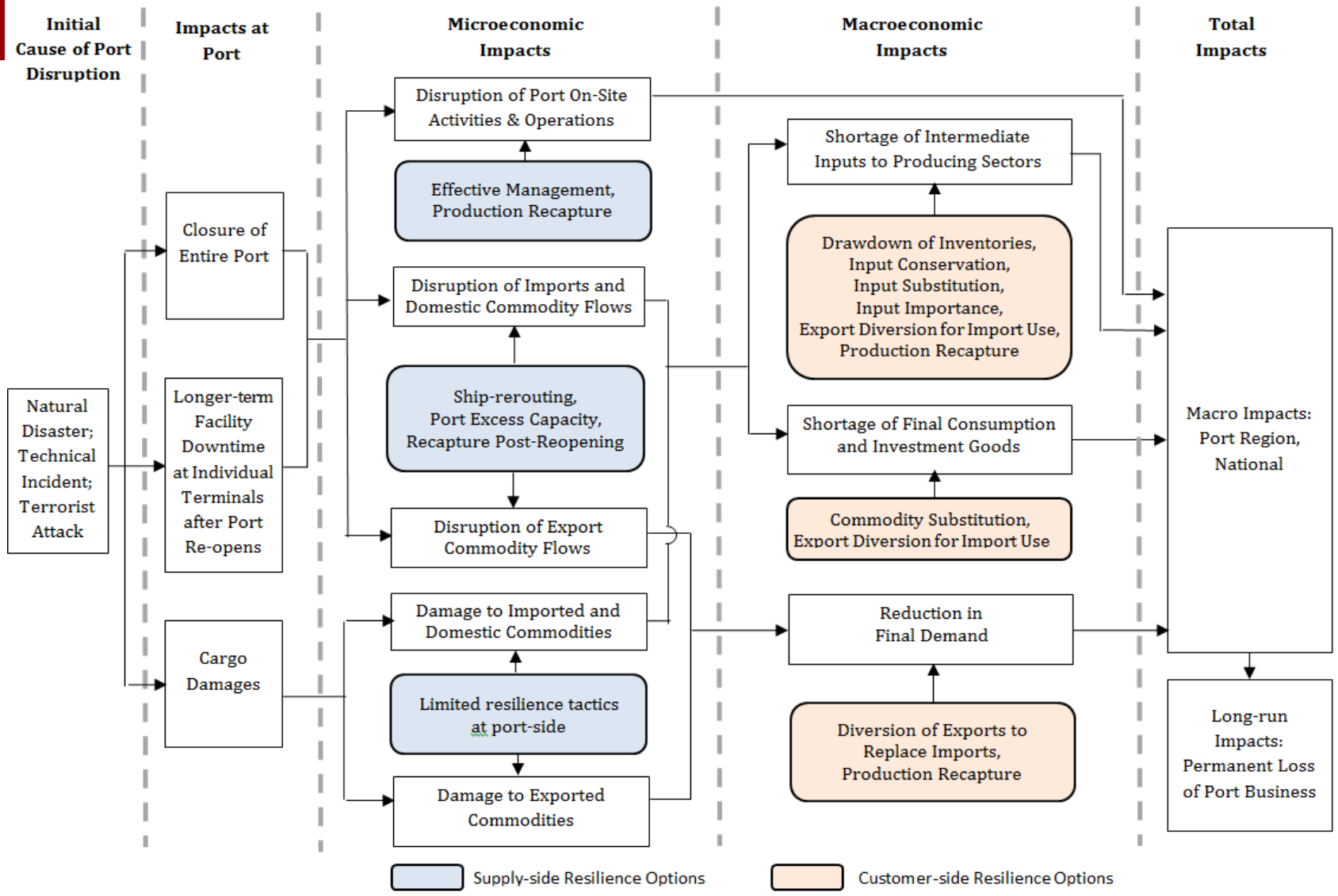


Figure 1. Analytical Framework for Estimating Total Economic Impacts of a Port Disruption

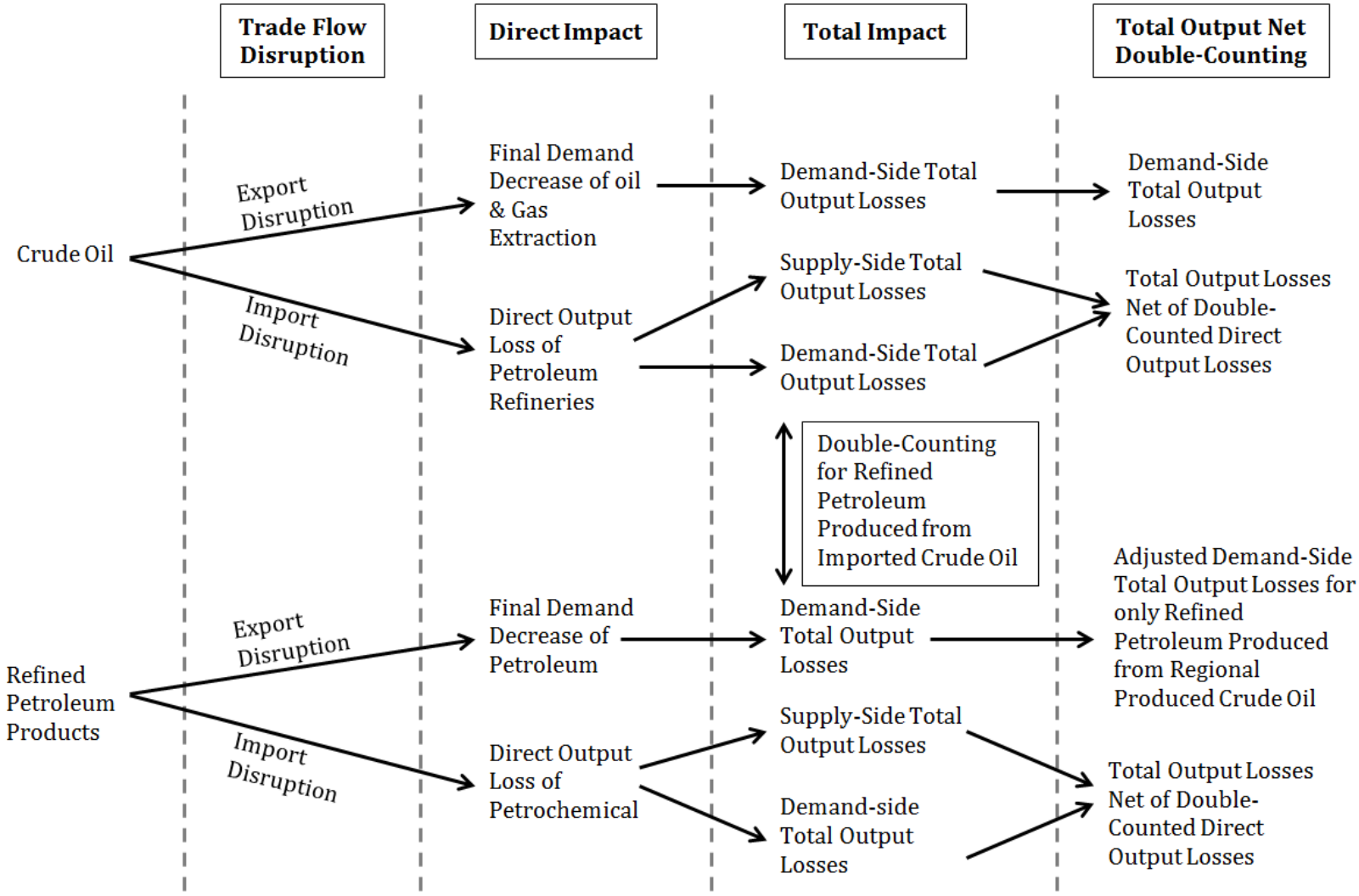


Figure 2. Double-Counting Adjustment of Export Disruption of Refined Petroleum

Economic Resilience

- Static:
  - General Definition: Ability of a system to *maintain function* when shocked.
  - Econ Definition: *Efficient use of remaining resources* at a given point in time to produce as much as possible.
- Dynamic
  - General: *Ability & speed* of a system to *recover.*
  - Economic: *Efficient* use of resources *over time* for investment in repair and reconstruction, including expediting the process & adapting to change.

- *Metric*: *averted losses as % of potential losses*

Rationale for Economic Resilience

- Two major perspectives:

  1. Include everything done to reduce losses, pre- and post-disaster (focus is on mitigation of property damage)

  2. Limit to actions implemented after the disaster hits (acknowledging that resilience is a process; things can be done to advance to build resilience capacity)
     - e.g., emergency drills, back-up generators, alternative suppliers
     - however, these are <u>not</u> implemented until after the disaster hits

- Can you reduce property damage post-disaster?
- No, but you can reduce business interruption!

Illustration: Economic 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 BI = $0
- Businesses relocated 2 to 4 months, BI = $16.1B
- *Resilience Metric*: Avoided Loss ÷ Max Potential Loss

$42.3B ÷ $58.4B = 72%

Table 1. Port Resilience Metrics

Resilience Tactic	Resilience Level	Explanation	Source
Inventories	59.5 million barrels of crude	Assumes excess crude oil stocks at tank farms and pipelines in PADD 3 Region in Year 2016 that exceed 10-yr average stock level can be readily accessed and utilized by PA/PB refineries	EIA (2017a)
Ship Re-routing	Up to 95% of the ships	Assumes up to 95% of ships can be re-routed to other ports in the Gulf Coast. Further assumes none of the rerouted crude oil will be transported back to Port Arthur MSA via pipelines, but will be used in refineries close to the diverted ports	Communication with USCG
Strategic Petroleum Reserve	20.8 million barrels	Assumes same amount of SPR release as during Hurricane Katrina	DOE (2017)
Export Diversion	Export disruption reduced by 58% Import disruption reduced by 6%	Assumes export diversion can only take place within each crude type (light/medium/heavy)	U.S. Census Bureau (2017)
Relocation	31.8% of refining activities at PA/PB	Represents excess and absorption capacity of refineries in some other parts of PADD 3	EIA (2017b)
Production Recapture	15 to 49% (by sector)	Adjusts HAZUS recapture factors to account for actual, vs. potential, recapture capability; 49% for petroleum refining and other manufacturing sectors)	FEMA (2015)

Table 8. Summary Results of Port Region Impacts for the Base Case (No Resilience)

Impact Category	Direct Output Change ($ millions)	Direct Output Change (%)	Total Output Change ($ millions)	Total Output Change (%)
Import Disruption				
crude oil	6,586	8.17%	7,661	9.50%
refined petroleum	4,154	5.15%	4,920	6.10%
sub-total (simple sum)	10,741	13.32%	12,581	15.60%
sub-total (eliminating double-counting)	7,055	8.75%	8,350	10.35%
Export Disruption				
crude oil	24	0.03%	34	0.04%
refined petroleum	3,694	4.58%	4,054	5.03%
sub-total (simple sum)	3,718	4.61%	4,087	5.07%
sub-total (eliminating double-counting)	74.7	0.09%	89.3	0.11%
Grand Total (simple sum)	**14,458**	**17.93%**	**16,669**	**20.67%**
Grand Total (eliminating double-counting)	**7,130**	**8.84%**	**8,439**	**10.46%**

Table 9. Summary Results of National Impacts for the Base Case (No Resilience)

Impact Category	Direct Output Change ($ millions)	Direct Output Change (%)	Total Output Change ($ millions)	Total Output Change (%)
Import Disruption				
crude oil	6,881	0.02%	31,093	0.09%
refined petroleum	4,232	0.01%	18,366	0.06%
sub-total (simple sum)	11,114	0.03%	49,460	0.15%
sub-total (eliminating double-counting)	7,370	0.02%	33,705	0.10%
Export Disruption				
crude oil	212	0.00%	567	0.00%
refined petroleum	3,694	0.01%	7,923	0.02%
sub-total (simple sum)	3,905	0.01%	8,490	0.03%
sub-total (eliminating double-counting)	1,229	0.00%	2,750	0.01%
Grand Total (simple sum)	**15,019**	**0.05%**	**57,950**	**0.18%**
Grand Total (eliminating double-counting)	**8,598**	**0.03%**	**36,454**	**0.11%**

Table 10. Regional Economic Impacts of a 3-Month Port Disruption (with Resilience)

(in million 2016 dollars)

Case	Direct Output Loss (1)	Direct Value-Added Change (2)	Final Demand Change (3)	Total Supply Change (4)	Total Demand Change (5)	Total Net S+D Change (6=4+5-1)	Total Net S+D Change (%)
A. Crude Oil Disruption (No Resilience)	$6,586	$6,466	$6,467	$6,864	$7,388	$7,661	9.5%
B. Inventory Resilience	$3,257	$3,176	$3,176	$3,416	$3,775	$3,934	4.9%
C. Re-routing Resilience	Re-routing has no effect on the impacts of crude oil disruption in the Port Region since we assume the re-routed crude oil will be used in refineries close to the alternative ports.						
D. SPR Resilience	$5,139	$5,036	$5,037	$5,366	$5,818	$6,044	7.5%
E. Export Diversion Resilience	$6,170	$6,057	$6,058	$6,427	$6,916	$7,172	8.9%
F. Relocation Resilience	Relocation has no effect on the impacts of crude oil disruption in the Port Region since this resilience tactic relates to utilizing excess capacity in refineries in other regions of the Gulf Coast.						
G. Production Rescheduling Resilience	a	a	a	a	a	$3,964	4.9%
H. All Resilience Adjustments	b	b	b	b	b	$1,699	2.1%

Table 11. Regional Economic Impacts of a 3-Month Port Disruption (with Resilience)

(in million 2016 dollars)

Case	Direct Output Loss (1)	Total Supply Change (4)	Total Demand Change (5)	Total Net S+D Change (6=4+5-1)	Total Net S+D Change (%)
A. Crude Oil Disruption (No Resilience)	$4,154	$4,281	$4,794	$4,920	6.1%
B. Inventory Resilience	$3,347	$3,421	$3,829	$3,903	4.8%
C. Re-routing Resilience	$106	$107	$119	$120	0.1%
D. Export Diversion Resilience	$31	$37	$37	$44	0.1%
E. Production Rescheduling Resilience	a	a	a	$2,553	3.2%
F. All Resilience Adjustments	b	b	b	$1.1	0.0007%

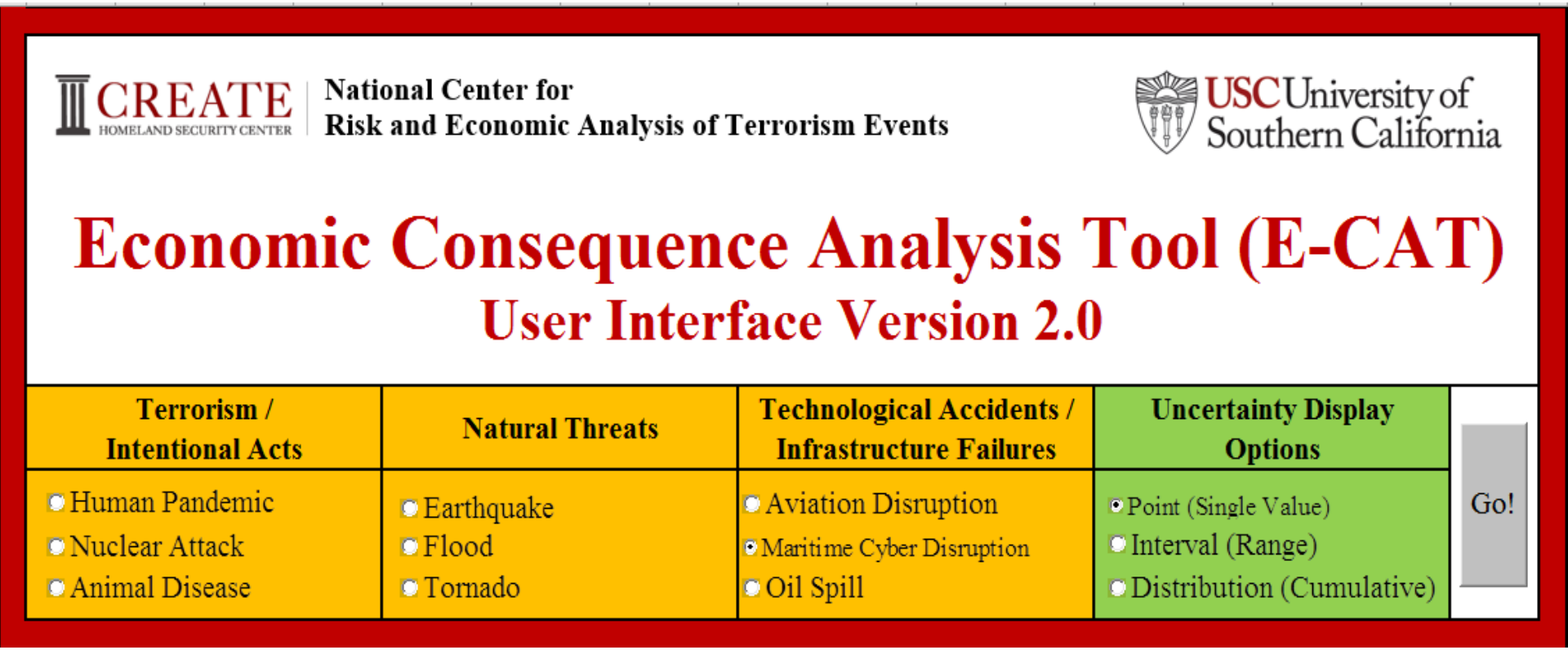
Table 12. Summary Results of Port Region Impacts for the Resilience Case

Impact Category	Total Output Change ($ millions)	Total Output Change (%)
Import Disruption		
crude oil	1,698.9	2.1%
refined petroleum	0.6	0.0%
sub-total (simple sum)	1,699.5	2.1%
sub-total (eliminating double-counting)	1,699.1	2.1%
Export Disruption		
crude oil	14.1	0.0%
refined petroleum	23.5	0.0%
sub-total (simple sum)	37.6	0.0%
sub-total (eliminating double-counting)	14.4	0.0%
Grand Total (simple sum)	**1,737**	**2.2%**
Grand Total (eliminating double-counting)	**1,714**	**2.1%**

Table 13. Summary Results of National Impacts for the Resilience Case

Impact Category	Total Output Change ($ millions)	Total Output Change (%)
Import Disruption		
crude oil	261.3	0.001%
refined petroleum	2.5	0.000%
sub-total (simple sum)	263.8	0.001%
sub-total (eliminating double-counting)	262.5	0.001%
Export Disruption		
crude oil	237.5	0.001%
refined petroleum	46.0	0.000%
sub-total (simple sum)	283.5	0.001%
sub-total (eliminating double-counting)	250.2	0.001%
Grand Total (simple sum)	**547.2**	**0.002%**
Grand Total (eliminating double-counting)	**512.7**	**0.002%**

E-CAT User Interface



Point Estimate: Default Value

CREATE HOMELAND SECURITY CENTER — National Center for Risk and Economic Analysis of Terrorism Events

Economic Consequence Analysis Tool

USC University of Southern California

Threat: Maritime Cyber Port Disruption

Option 1: Input Single Parameter Estimate

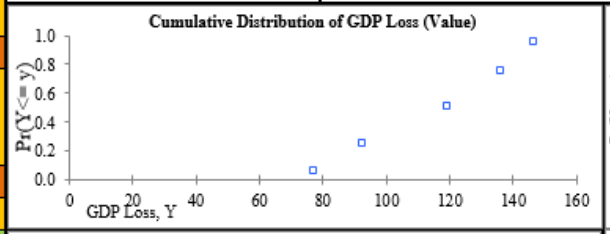
Reset Default | Main Menu | Print Results

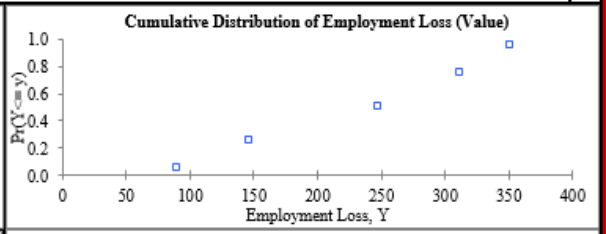
Input Area: Input values in yellow boxes
(grey boxes are non-applicable)

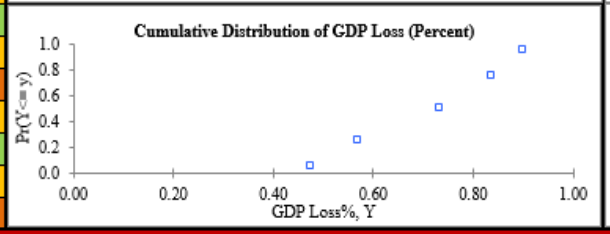
Magnitude	Time of Day
136 billions of $ trade (Defintion)	
Select value between 15 and 136.37	
Duration	**Location**
Economic Structure	**Restroation**
Resilience - Inventory	**Resilience - Rerouting**
N/A (Defintion)	N/A (Defintion)
Resilience - Recapture	**Resilience - Conservation**
N/A (Definition)	N/A (Definition)

Results Area

		GDP Loss		Employment Loss	
		billion dollars	percent	thousand jobs	percent
Economic Impacts: (all in $2012)	**Mean**	**121.72**	**0.75**	**257.53**	**0.20**
	5% Quantile	77.24	0.48	89.87	0.07
	25% Quantile	92.57	0.57	147.56	0.12
	50% Quantile	119.39	0.73	248.35	0.19
	75% Quantile	136.39	0.84	312.60	0.24
Distribution Charts:	95% Quantile	146.69	0.90	351.49	0.27







Adjust Ship-Rerouting Resilience = 35%

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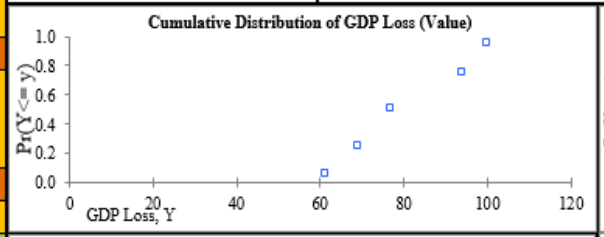
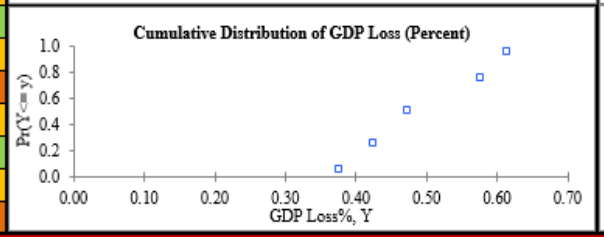
Duration	**Location**
Economic Structure	**Restroation**
Resilience - Inventory	**Resilience - Rerouting**
N/A (Defin)	35% (Defintion)
Resilience - Recapture	**Resilience - Conservation**
N/A (Definition)	N/A (Definition)

Results Area

		GDP Loss		Employment Loss	
		billion dollars	percent	thousand jobs	percent
Economic Impacts: (all in $2012)	Mean	81.23	0.50	105.33	0.08
	5% Quantile	61.45	0.38	30.72	0.02
	25% Quantile	69.12	0.43	59.51	0.05
	50% Quantile	77.06	0.47	89.05	0.07
	75% Quantile	94.03	0.58	152.70	0.12
Distribution Charts:	95% Quantile	100.13	0.62	176.09	0.14





Conclusion

- Refined a methodology for ECA of port disruptions
  - Applied to medium-size port, but broadly applicable
  - Focused on resilience tactics that dampen impacts
- Findings
  - Regional economic impacts after resilience: minor
  - National economic impacts after resilience: almost nil
  - Recent shale oil revolution promotes resilience
  - Post-disaster resilience cheaper than pre-disaster mitigation
- Policy Issues
  - Are all critical infrastructure facilities really critical?
  - Should regional impacts count?