

## Lack of Resilience in Transportation Networks: Economic Implications

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H--H

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## Ian Triggers Port, Rail Closures, Straining Supply Chain



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🗑 eShipper 🥼 Sat., Oct. 1, 2022 👩 4 min. read

### A Resilient Supply Chain Starts With Full Visibility



Dan Shey Forbes Councils Member Forbes Technology Council COUNCIL POST | Membership (Fee-Based)

Sep 30, 2022, 09:45am EDT

# How leveraging connected experiences in logistics can build resilient supply chains

Advances in cloud data storage, artificial intelligence and cellular networks are all collectively driving a more connected experience in transport and logistics





What Makes Complex Systems (Communities) Susceptible to Threat?



After Linkov and Trump, 2019



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# Risk --- "a situation involving exposure to danger [threat]."

Security -- "the state of being free from danger or threat."

Resilience -- "the capacity to recover quickly from difficulties."

### Don't conflate risk and resilience

'Risk' and 'resilience' are fundamentally different concepts that are often conflated. Yet maintaining the distinction is a policy necessity. Applying a riskbased approach to a problem that requires a resilience-based solution, or vice versa, can lead to investment in systems that do not produce the changes that

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Definitions by Oxford Dictionary

## **Crisis Management, Risk and Resilience**



Time





## **Assessment using Resilience Matrix**



costs and benefits of different courses of action

A matrix approach to community resilience assessment: an illustrative case at Rockaway Peninsula

Cate Fox-Lent<sup>1</sup> · Matthew E. Bates<sup>1</sup> · Igor Linkov<sup>1</sup>

## **Network-based Resilience Theory?**



A set of possible damages stakeholders want the network to be resilient against (E)

After Ganin et al., 2016

$$R = f(\mathcal{N}, \mathcal{L}, \mathcal{C}, \mathbf{E})$$

## **Poor Efficiency:**

System cannot not accommodate a large volume of commuters driving at the same time.

Traffic congestions are predictable and are typically of moderate level.





## Lack of Resilience:

System cannot recover from adverse events (car accidents, natural disasters)

Traffic disruptions are not predictable and of variable scale.



## **Transportation Network Model**



## **Modeling Disruptions**

Case I Natural Disasters	Case II Random Disruptions	Case III Attacks Disabling Traffic Control	Case IV Attacks Locking Traffic Control					
Links (Roadways) Only	Links (Roadways) and Nodes (Intersections)	Nodes (Intersections) Only						
Modeled Fractions of A	Affected Nodes/Links							
From 5% to 100% with the step of 5%								
Selection of Nodes/Lin	ks Affected by a Disrupt	ion						
Proportionally to Length at Random	Deterministica	Uniformly at Random ally by Length, Load, and Betweenness						
Disrupted Roads and/o	or Intersections							
Speeds reduc	ed to 1 km/h	Speeds reduced by 50%	Half of speeds are reduced 80%, the other half is increased 20%					

## Impact of Transportation Network Disruptions on Travel Time



## Integrating REMI Model



Model structure of TranSight

## Repurpose to Study Economic Implications of Resilience (or lack thereof)



## Impact of Efficiency-Related Delays



## Impact of Resilience-Related Delays

![](_page_18_Figure_1.jpeg)

## Lack of Resilience: Impact on GDP Random Disruptions are Much More Consequential

![](_page_19_Figure_1.jpeg)

### **Temporal Dimension**

![](_page_20_Figure_1.jpeg)

## **Economic Impact – Travel Sector in Georgia**

![](_page_21_Picture_1.jpeg)

![](_page_21_Figure_2.jpeg)

### what does **REMI** say?<sup>sm</sup>

## Freight Modeling in CA

- 1. Data Connections
  - Identify Interconnections
- 2. Data Confidence
  - Derive known commodity
    - flows from data

![](_page_22_Figure_7.jpeg)

![](_page_22_Picture_8.jpeg)

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### Data Fusion and Optimization Using AI and Resilience Modeling

![](_page_23_Figure_1.jpeg)

### Replica Data: Connecting Entry Points, Warehousing and Consumers

![](_page_24_Figure_1.jpeg)

LABORATORY

### **Presentation Overview**

- Tools:
  - Freight Volumes
  - Scenario Comparison Tool
- Problems we are addressing:
  - I. Supply Chain Resilience Quantification
  - II. Natural Disaster Risk and Resilience
  - III. Zero-Emission Refueling Station Prioritization
  - IV. Multi-Objective Equity Optimization

Multi-Objective Equity Optimization

![](_page_25_Picture_10.jpeg)

Supply Chain

Resilience

Zero Emission Refueling Station

![](_page_25_Picture_12.jpeg)

![](_page_25_Picture_13.jpeg)

![](_page_25_Picture_14.jpeg)

## Supply Chain in USACE Projects

- Examined 5,000 projects from the last decade
  - USACE NWD projects
- Scale and magnitude of overruns in 2021 is double the baseline amount observed in the last 10 years

![](_page_26_Figure_4.jpeg)

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### Result 2: Material Requirements How do we predict a future shock (before it hits us)?

### Widely used Commodity Life Cycle Model

### • EPA EEIO Tables

### How Much Nickel?

### NAICS Category Descriptions

Unnamed: 0	1111A0/US	1111B0/US	111200/US	111300/US	111400/US
ron ore/resource/ground/kg	2.067140e-	3.857260e-	2.025340e-	1.349760e-	1.538790e-
	04	04	04	04	04
Nickel/resource/ground/kg	3.418990e-	5.411910e-	3.137640e-	2.057260e-	2.461800e-
	08	08	08	08	08
Phosphate	2.877245e-	1.623147e-	3.128757e-	2.100242e-	2.244069e-
ore/resource/ground/kg	03	02	03	03	03

#### NAICS Code 1114 Description

This industry group comprises establishments primarily engaged in growing crops of any kind under cover and/or growing nursery stock and flowe "Under cover" is generally defined as greenhouses, cold frames, cloth houses, and lath houses. The crops grown are removed at various stages of maturity and have annual and perennial life cycles. The nursery stock includes short rotation woody crops that have growth cycles of 10 years or let

### Data Routinely Available on USACE Projects

### •USACE Project Description

SELECTED PROJECT This project entails clearing and grubbing hybrid poplars, blackberry plants and f m debris from approximately 45 acres of land. Disposal of material cleared and grubbed, tillage of pproximately 71 acres, seeding of grasses on approximately 66 acres, and seeding of fall oats on ap oximately 5 acres designed for future establishment of riparian trees and shrubs. Approximately 6.

![](_page_28_Figure_0.jpeg)

USACE Project Description this project entails clearing and grubbing hybrid poplars, blackberry plants and farm debris...

For this project which NAICS Economic Bins are most applicable ? Score all 400+ bins.

Neural Network Based Natural Language Processing (NLP) Model

Trained on ALL Wikipedia Entries

US Army Corps of Engineers •

![](_page_28_Picture_5.jpeg)

Greenhouse, nursery, and floriculture producti... 0.727693

Vegetable and melon farming. This industry gro... 0.712372

Other crop farming'. This industry group compr... 0.709028

Farm machinery and equipment manufacturing'. T... 0.676935

### Result 2: Material Requirements Project Reliance on Foreign-Sourced Minerals - Nickel

### • **Base Project**: USACE NWD Projects (2000 - 2020)

![](_page_29_Figure_3.jpeg)

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## **Vision for System Resilience**

![](_page_30_Figure_1.jpeg)

### The case for value chain resilience

Igor Linkov, Savina Carluccio, Oliver Pritchard, Áine Ní Bhreasail, Stephanie Galaitsi, Joseph Sarkis and Jeffrey M. Keisler Management Research Review © Emerald Publishing Limited 2040-8269 DOI 10.1108/MRR-08-2019-0353

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**Risk, Systems and Decisions** 

Igor Linkov Benjamin D. Trump

## The Science and Practice of Resilience

NATO Science for Peace and Security Series - C: Environmental Security

### **Resilience and Risk**

Methods and Application in Environment, Cyber and Social Domains

> Edited by Igor Linkov José Manuel Palma-Oliveira

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NATO OTAN *to supported by* The NATO Science for Peace and Security Programme Risk, System and Decisions

Igor Linkov Benjamin D. Trump Jesse M. Keenan Editors

COVID-19: Systemic Risk and Resilience

![](_page_32_Picture_13.jpeg)

![](_page_32_Picture_14.jpeg)

![](_page_33_Figure_0.jpeg)

System Affected by **Threats:** Taxonomy

DOI: 10.1111/risa.13577

### The Need to Reconcile Concepts that Characterize Systems

S. E. Galaitsi <sup>(D),1</sup> Jeffrey M. Keisler <sup>(D),2</sup> Benjamin D. Trump <sup>(D),1</sup> and Igor Linkov <sup>(D),\*</sup>

![](_page_34_Figure_0.jpeg)

## **Field of Supply Chain Resilience is New**

#### **Web of Science Publications**

![](_page_35_Figure_2.jpeg)

![](_page_35_Picture_3.jpeg)

## The case for value chain resilience

Igor Linkov, Savina Carluccio, Oliver Pritchard, Áine Ní Bhreasail, Stephanie Galaitsi, Joseph Sarkis and Jeffrey M. Keisler

Management Research Review © Emerald Publishing Limited 2040-8269 DOI 10.1108/MRR-08-2019-0353

![](_page_36_Picture_0.jpeg)

### Supply-and-Demand Networks – challenges

#### SDNs operate as engines for strategic surprise – many critical vulnerabilities emerge only at the system level

![](_page_36_Figure_4.jpeg)

RSDN will explore SDN fragilities and possible mitigations – e.g., procurement policies, strategic reserves, etc.

## **RESILINC – example of metric-based approach**

### BIOGEN EVENT RESPONSE PROCEDURE WITH RESILINC

![](_page_37_Figure_2.jpeg)