Understanding complexity

The marine transportation system (MTS) is finding itself uncomfortably in the news as pandemic-driven changes in trade and other factors reveal previously overlooked vulnerabilities and complex dependencies. Port operators, cargo owners, and consumers alike have found that supply chain resilience has its limits when multiple disruptions converge. A better understanding of complex disruptions may help to foster a more robust MTS in an increasingly interdependent world.

The blockage of the Suez Canal by the grounding of container ship *Ever Given* during the pandemic in March 2021 was an early indicator of this issue. Simultaneously, in March 2021 alone, 200,000 seafarers were stranded on ships owing to COVID-19 restrictions, and labor shortages and outbreaks were happening globally, further stressing the situation. Favorable tides and good decisions helped resolve the situation relatively quickly, but the event highlighted the challenges of an already-stressed global supply system. It could have been much worse, with cascading supply chain impacts throughout the MTS.

Multiple risks

Increasing traffic through a fixed number of ports however makes the MTS vulnerable to disruptions, including accidents, natural disasters, and deliberate attacks. Automation improves efficiency and also pushes the system closer to its maximum capacity, leaving little room for error. Technology also carries risks related to cybersecurity, power disruptions, and the need for new kinds of skilled labor. Climate change threatens to flood docks with rising sea level while intensifying storms. Busy ports are a place where all of these risk factors can coincide, and when they do, the consequences may be greater than the sum of the parts.

To date, most research and contingency planning has focused on single-event disruptions such as an oil spill, natural disaster, or security incident. There has been little analysis of the cascading impacts of multiple disruptions that build on each other in complex ways. The limited research suggests that modeling the impact of multiple vector disruptions and multiple MTS targets can help policymakers, business leaders, and others anticipate, plan for, mitigate, and rapidly recover from future disruptions.

With this as the background, a team of three US Department of Homeland Security university centers of excellence – CCICADA at Rutgers University, CREATE at the University of Southern California, and CAOE at Arizona State University – is working to identify risk factors to the MTS to better understand how they interact and quantify the potential for cascading consequences from complex disruptions. The research also investigates pre- and post-incident mitigation and resilience strategies to reduce risks.

What the team has learned

The research is still in its early stages, and the primary methodology at this point is to listen to experts and learn how complex disruptions have impacted commerce or might in a future where technological, financial, and environmental change leads to new possibilities. The team has interviewed professionals from major shipping lines, trade associations, port authorities, freight forwarders, the oil and energy industry, and the US Coast Guard, just to name a few. The questions asked are references to their experiences in the past – and ongoing – disruptions and emerging risks. The research team has had some surprising responses from the simple question of what keeps you up at night because they are also interested in improving resilience. It has been equally revealing to ask experts what changes they would make if they had the power to do so.

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While the responses have been as varied as the industry itself – as they say, if you have seen one port, you have seen one port – there have been some common themes. Cybersecurity, in its myriad forms, is a nearly universal concern. Electrification is clean and efficient but significantly depends on old infrastructure and a vulnerable grid. Simply having access to the waterfront is a challenge in many locations, as non-maritime players and growing coastal population centers seek waterfront property, pushing out any marginal maritime commerce organizations that might have provided extra capacity and resilience in an emergency.

The research is also focused on quantifying the cascading economic consequences of complex disruptions. The team will be building on the USC CREATE research team's previously developed Economic Consequence Analysis Tool (E-CAT) that is well-suited to addressing supply chain issues. It works by running hundreds of simulations with a complex computable general equilibrium model and then performing regression analysis on the results.

Introducing a new tool

One of the research goals is to improve that tool by drawing on more extensive data, especially at the port level, and enabling it to consider multiple, simultaneous disruptions. The new tool, Complex Maritime Economic Consequence Analysis Tool (M-CAT), will have a high level of accuracy and broad real-world applicability. The M-CAT will account for uncertainties, thereby providing confidence intervals over a range of estimates and an improved reflection of actual economic activity.

The team expects that M-CAT and its associated research will improve understanding of how complex disruptions impact commerce and provide a credible, independent measure of the value of a well-functioning MTS to society. In combination with other tools and information, this can help policymakers and business leaders make sound decisions on infrastructure investments, training and education programs, contingency planning, and long-term business strategies.

The past few years have brought far too many disruptions to our ports and harbors, including trade disputes, a global pandemic, considerable shifts in cargo volumes, cyberattacks, and the old standbys of natural disasters, accidents, and daily business challenges. As of this writing, the Russian invasion of Ukraine is impacting the MTS in ways as varied as stranded seafarers, economic sanctions, war risk insurance premiums, and the increasing price of food and energy. Complex disruptions appear to be here to stay. ▪

The researchers seek input from professionals across industry, academia, and government. If you are willing to share your perspectives on the topic, please contact Dr Fred Roberts at froberts@dimacs.rutgers.edu.

ABOUT THE AUTHOR

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