ABSTRACT

Ports play a vital role in the economy of nations and provide a critical link in the supply chain. Ports form the gateway by which essential goods are received within large geographic regions. Because of their function, ports are exposed to substantial risk of flooding, storm events, sea-level rise, and climate change. The resiliency of ports is essential for the economy, the people, and national readiness. The contribution of this research work is in providing a methodology to quantify port resiliency that is applicable at the individual port level and regionally. The research approach first defines a quantifiable measure of systematic resiliency. Then this measure quantifies the resiliency of six ports within the Southern U.S. impacted by Hurricane Matthew (2016). Based on the analysis of these individual ports, a regional resiliency assessment is then applied to quantify the regional resiliency of the impacted area. In general, the results showed that regionally, ports are more resilient to disruptive events than the individual ports that make up the region. This was likely because as one port enters the disrupted state, another may be entering the recovery state providing regional continuity. This may suggest that port clusters rely upon each other during disruptive events to increase the overall resiliency of the waterborne commerce. In general, the study ports struggled to absorb the impact of the storm and subsequent closures, whereas adaptability and recovery were significantly larger.

INTRODUCTION

Hurricanes, oil spills, and labor disputes can all be sources of port disruptions. Hurricane Sandy in October 2012 closed the Port of New York/New Jersey for over a week from full operations. The hurricane caused flooding, loss of power, and damages to the port that prevented the ports from reopening immediately. It was estimated by the Port Authority of New York and New Jersey (PANYNJ) that the port closure cost $717 million [1]. Between the time the port partially reopened (three days after landfall) and the time the port returned to full operation (eight days after landfall), dwell times of vessels trying to enter the port climbed as high as 150 hours [2]. The overall impact of a disruption on a port is a function of vulnerability of the port and the severity of the disruption. The resilience of ports and inland waterways is critical for maintaining the flow of essential goods throughout the United States and is critical to national security and defense readiness.

According to the National Science Foundation, resiliency is the ability “to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events”. [3] This definition can be quantified for a variable between zero and one for all discrete systems.

RESULTS OF DAILY ARRIVALS

The results focus on containerized cargo vessel arrivals and dwell times because only this vessel class was prevalent at all six ports. The results first present functionalitivity plots generated from the AFS data for each of the six x-axes shown in gray in Figure 5-2. The average daily arrivals per port and the region as a whole. Daily containerized cargo vessel arrivals and average daily dwell times were used as the performance functionality of interest.

The figure above shows the daily arrivals for containerized vessels at each of the study ports and regionally. In the days leading up to landfall, the storm threatened nearly the entire eastern coast of the Southeast US, ultimately maintaining adverse effects in the Port of Savannah. The daily corresponding to the event (t2), the end of the absorption state (t3), the end of the disruptive state (t4), and the end of the recovery state (t5) are also provided for the regional impact. The absorption performance of the disruption was expected because closures tend to bring a sudden halt to operations. With no vessels arriving, a rapid drop in vessel arrivals was expected.

Many of the ports in the study reopened relatively quickly, following the passage of the storm resulting in high disruption state values. Recovery was measured by an average dwell time of 59 and a regional recovery value of 0.90. This suggest that not only were the ports able to reopen quickly after the storm, they were accommodating as many vessels, or in some cases even more vessels, than prior to the storms passing.

Overall, the resiliency of each port was limited by its ability to absorb the impact of the event. The regional resiliency value 0.145 with the Port of Jacksonville having the largest resiliency value of 0.211. This was unexpected because of Jacksonville’s proximity to landfall. Ports Canaveral and Charleston both measured the lowest resiliency values of 0.10. Charleston’s resiliency was limited by its ability to adapt (i.e. end the disrupted state). This was likely because Charleston was closest to landfall, possibly suffering infrastructure damage.

CONCLUSION

The results showed that regionally, ports are more resilient to disruptive events than the individual ports that make up the region. Based on the findings of this research, it is expected the proposed resiliency quantification methodology can be expanded to other systems and areas of science. Future researchers will be able to build upon this work by developing a resiliency measure based on the quantification methodology described here.