ECONOMIC IMPACT OF FLOW DISRUPTION IN SEAPORTS[1]

***Khosrow Moshirvaziri**, Information Systems Dept., California State University, Long Beach, Long Beach, CA 90840, 562-985-7965, moshir@csulb.edu*
***Behnam Bahr**, College of Engineering, California State Polytechnic University, Pomona, CA 91768, 909-869-2600, bbahr@csupomona.edu*
***Mahyar A. Amouzegar**, College of Engineering, California State Polytechnic University, Pomona, CA 91768, 909-869-2472, mahyar@csupomona.edu*

ABSTRACT

This paper focuses on quantifying the economic impact of cargo flow disruption in monetary form, and devising metrics that would further enhance our understanding of the vulnerabilities of supply chain network in general, and assess the impact of catastrophic events on intermodal cargo throughput through the SPB ports, in particular.

INTRODUCTION

California is home to the nation's premier international seaports. The two ports of Southern California, ports of Los Angeles and Long Beach, alone serve as the state's major economic engine with significant impact at the national level as well. Over 41 percent of containerized imports and 30 percent of the country's exports pass through California's ports. These ports handle an estimated $500 billion of goods annually [1]. The two ports of Los Angeles and Long Beach, which are referred to as the San Pedro Bay (SPB) ports or twin ports, generate about $10 billion annually in state and local tax revenues [2].

Preserving the operational health of the ports is not only critical to the continuity and improvement of the State's economy (and in particular Southern California's economy), but it is also vital for maintaining the country's overall economic health. It is the primary objective of this research to develop systematic methods to better understand the vulnerabilities of the supply chain network and assess the impact of catastrophic events on intermodal cargo throughput through the ports of Los Angeles and Long Beach. Quantifying the impact and devising metrics that estimate the economic impact of cargo flow throughput in monetary form is the main focus of this investigation.

BACKGROUND

Our national economy depends on reliable freight and containerized transportation systems, mainly through the seaports, to link suppliers and markets throughout the nation and across the globe. From a network perspective, ports serve as the gateways or source nodes into the state and national supply chain networks through which imports and exports pass. Given the steady growth in the global trade with other nations and in particular in Asia and South America, the operational stability of our ports infrastructure is of great import and naturally their potential vulnerability to disruption is a major concern to policymakers. Closure of our ports for any extent of time, may severely disrupt supply chain

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networks at local, state or national level. Therefore, disasters whether naturally such as Tsunami or act of terrorism or labor strikes have the potential to severely impact the overall economy.

Roughly one-quarter of the United States imports and 17% of its exports pass through the U.S. ports on container ships. These imports include finished or intermediate products, which are vital to maintaining U.S. industries. Manufacturers utilizing the widely adopted “Just-in-Time” inventory or “Sense and Respond” logistics in their operation are particularly vulnerable to any disruption to the supply chain. These models, by their nature, impose limited inventory and safety stock and therefore they are very sensitive to any perturbation to the system. The lack of key parts may lower output, employment, and income for individual companies by amounts larger than the value of the delayed part—and in areas and businesses far removed from the port where a disruption occurred. Major concerns about interruption in the flow of container traffic have focused on terrorist attacks in the past decade. However, the recent disaster in Japan clearly demonstrated that severe economic losses could also result from extreme weather or other natural disaster causing disruptions elsewhere in the supply chain [3].

Recent study [9] the SAFRR scenario, published by the United State Geological Survey (USGS) has explored the effects of a hypothetical tsunami from a distant source in Alaska on the coast of Southern California. It investigated that if a magnitude 9.1 earthquake hits in coastal waters off the Alaskan Peninsula, waves could flood Southern California’s low-lying coastal areas, forcing up to 750,000 residents to evacuate and monetary damage to marinas, businesses and homes could range from $3.5 billion to $6 billion. The cost of physical damage resulting from such disaster is estimated at:

1. $100M in damages to the twin Ports of Los Angeles (POLA) and Long Beach (POLB),
2. $700M in damages to marinas, and
3. $2.5B in damages to buildings and contents (properties) in the tsunami inundation zones.

These figures do not account for economic impacts from damage to roads, bridges, railroads, and agricultural production or fires in fuel storage facilities [4]. Furthermore, the strongest impact of such tsunami is predicted to occur in the San Pedro Bay area, an area with the most significant infrastructure developments, and with the most vital to commerce at the regional, state, and national economy.
As stated earlier, preserving the stability and operational health of the ports is not only critical to the continuity and improvement of state’s economy but also vital for maintaining the overall country’s economic health, hence the significance of this research.

California’s Ports - Over 40% of containerized imports and 30 percent of the country’s exports pass through California’s ports. These ports handled an estimated average of $500 billion of goods annually. The twin ports together generate over $10 billion annually in state and local tax revenues [2].

The Economic Impact on the Twin Ports

About $12.1 billion direct and an additional $5.5 billion in local industry indirect sales are generated through businesses that receive imported goods or export through the Los Angeles Port. Personnel working for businesses exporting and importing goods through the Los Angeles Port spent about $4 billion annually. The port supports 1.1 million jobs locally and over 3.3 million nationwide. It generates over $21.5 billion in federal tax revenue for the state.

Containerization is an important element of innovation in logistics and security that revolutionized freight handling in the 20th century. The POLA is the largest container port by volume in the United States since 2000 (633,000 TEUs[2] in 1980 to 8.4 M TEUs in 2007).

An average of $100 billion of cargo passes through the Port of Long Beach on annual bases and over $5 billion is spent by domestic and international shippers and steamship companies in Long Beach area. Annual wholesale services for goods imported through the port are around $10 billion. The port also supports over 300,000 jobs locally, 370,000 in the state of California, and over 1.5 million nationally, paying over $14 billion in wages and personnel salary in the region. Port of LB is the second busiest port in the United States, with 6.3 million TEUs in 2010 [5]. Overall, just under 12 million TEUs passed through the SPB ports in 2009, down from 14.28 million TEUs in 2008, and climbing back again in 2010 by more than 24 percent. It is anticipated that cargo nearly tripling by the year 2020[6].

The catastrophic events of the past decade, whether natural or manmade, have necessitated the need for a more systematic approach to assess and predict supply chain disruptions and plan for recovery procedures in advance of similar future events. To help reduce such vulnerabilities to the supply chain network, there have been continuous support by federal agencies and particularly by the Department of Homeland Security (DHS), Department of Transportation (DOT), and Department of Defense (DOD) in funding research projects and studies which may shed light on a systematic, scientific approach to deal with port disruption problems. In the SAFRR scenario economic impacts are measured by the estimated reduction in California's gross domestic product (GDP), the standard economic measure of the total value of goods and services produced. Economic impacts are derived from the physical damages from the tsunami as described by Porter and others (2013).

The economic impacts are first calculated without resilience, the ability of the economy to adjust to disruptions in ways that mute potential negative impacts. There are many types of resilience, including using existing inventories of materials, using unused capacity, conserving inputs, substituting for disrupted supplies, recapturing production after the disruption is restored, and many others. A method for estimating resilience, identified in the port system and sectors affected by property damages is applied to indicate potential reductions of direct and total economic impacts.

METHODOLOGY

In this study the economic impact is simulated using the loss in volume (TEUs), Tonnage data in millions of Short Tons (MST) and data values received from Los Angeles Custom District (LACD) waterborne inbound in US dollars (USD). We designed a stochastic simulation model based on the Empirical distributions, carefully drawn from statistical analysis of the Freight data, in an ExtendSim9 [7] environment. The lengthy mathematical derivations and statistical details and its design features are out of the scope of this paper but may be sought from the research sponsor agency. Freight movement data is usually collected by the local, regional, and mostly by state agencies. Although many firms track trade activities and shipping industry to build their own database for profit. These databases are used for prediction of volume/value and bottlenecks in the system transportation and supply chain modeling efforts. Unfortunately however, there is no integrated approach to both modeling as well as data collection efforts by various firms and agencies. A great level of discrepancies exists between data collection methods used which often leads to erroneous results and confusion between data sources.

[2] Twenty-foot Equivalent Unit (TEU) is a standard measurement used in the maritime industry for containers.

One important characteristic common to all sorts of simulation models is that they can become extremely data intensive if they are to be accurate and useful for the purposes they are intended. If the objective is to exploit the full capabilities of simulation models and support statewide freight planning and assess ports and terminal disruptions' economic impact, the required data must be collected and maintained over time in details as well as in aggregate forms and in a unified approach. For example, Inbound and Outbound trade activities at the SPB ports must be stored over smaller time span, say on hourly or daily basis in addition to monthly and annual aggregate figures. Typical monthly trade rate is diminishing in the winter months and rise from mid-summer to early fall.

ECONOMIC IMAPCT SIMULATOR

Figure 2 below illustrates the User Interface Panel of the Economic Impact Simulator (EIS). Figure 3 illustrates typical output, losses measured in billions of US dollars for a hypothetical one day, one week, and two months shutdown of the twin ports. At the setup, on the left margin, the user sets the scenario level. This is simply the event disruption duration that will be simulated at a random time, day, month, and year for the next decade (in the range of 2014 to 2025). The simulation processes make use of SPB databases distributed by various local, state and federal government agencies. These databases are linked to internal processes within the simulation model to perform various statistical analyses and compute predictors using mathematical models. In addition to computing average behavior of various systems' parameters, the user may enable/disable more advanced Feature. At the expense of simulation RUN TIME and availability of appropriate databases (such as real data on Inbound/Outbound seasonal trends at the ports) more accurate estimates of economic loss due to disruption may be computed.

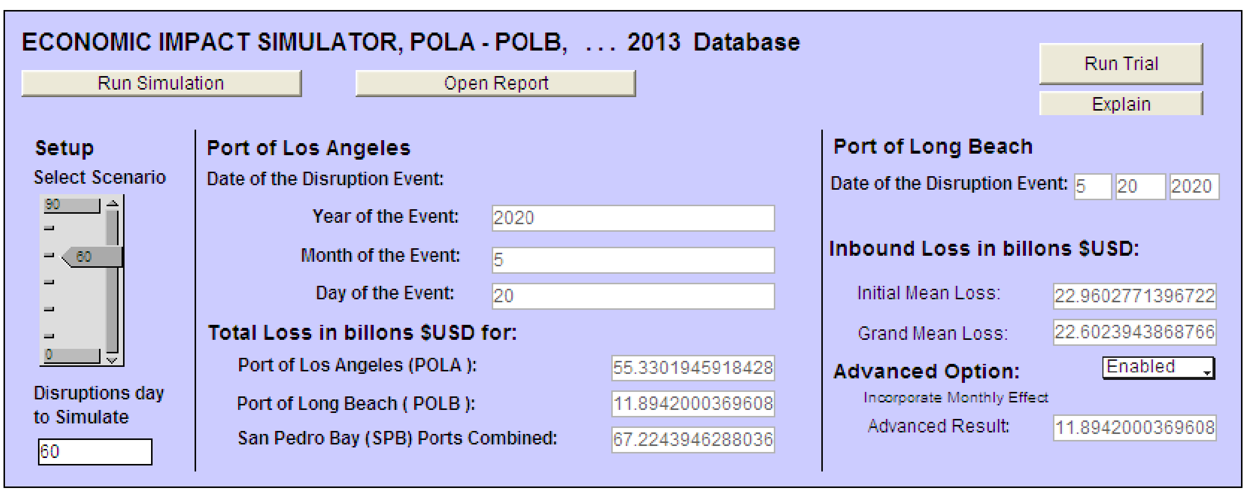
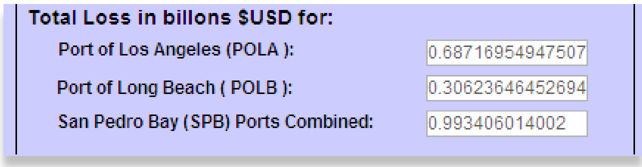
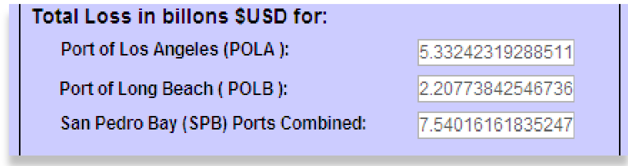


Figure 1: User Interface Panel of the Simulator displaying losses in billions of USD

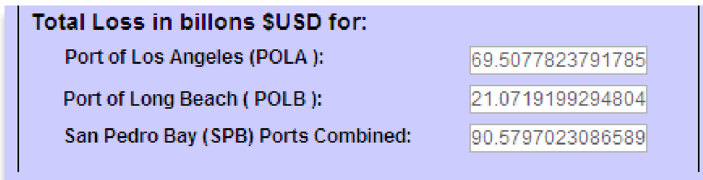
Our Simulation Module was built in ExtendSim9 [7] environment and may be modified to predict accurate account of Inbound, Outbound, Loaded, Emptied, and Total containerized trade (in TEUs) at the San Pedro Bay Ports or at other West Coast ports such as Oakland, Tacoma, Seattle, and Seattle ports or at those of Canadian; Vancouver, Robert Bank, and Prince Rupert ports, provided access and availability of required databases. The most important quantity of interest in this study, however, is the inbound trade volume at the ports of Los Angeles and Long Beach that could be lost due to various disruption scenarios, including tsunami, human error, strike, or other events.



a. 2014: one day Shutdown Scenario Run



b. 2016: one week Shutdown Scenario Run



c. 2018: 60 days Shutdown Scenario Run

Figure 3: Simulation Output.

Snapshot of various scenarios:

The simulation model is configured to provide containerized trade volume loss due to a port disruption of up to three months or 90 days. This setting can be extended to measure impacts of longer port shutdowns. Panels (a) through (c) in Figure 3 are snapshots, illustrating simulation run results for three different scenarios of one day, one week, and two months disruptions, respectively.

These results are in line with the estimates submitted by various SPB Port officials or those reported during the recent (2012) Strike at the twin ports. Other studies have focused on the economic impacts of threats that close the ports. Another analysis of a potential tsunami scenario affecting the California economy through disruption of port trade movement is a 2005 study by Borrero et al [4] estimated economic impacts to the southern California economy in the range of $7 to $40 billion from a locally generated tsunami that closes San Pedro Ports for as much as 1 year. There have also been several studies of the economic impacts of non-tsunami events affecting POLA and POLB. Analyses of an 11-day labor lockout produced a range of estimated national impacts of as much as $1.94 billion/day [7]. In which an investigation of a potential terrorist attack that closes the twin ports for 30 days resulted in a $29 billion impact to the California economy.

CONCLUDING REMARKS

This paper investigates the vitality of SPB ports as a pair of significant gateways to the state and notional supply chain network. It reveals a potential economic impact of cargo flow disruption in monetary measures, whether due to a catastrophic event such as a tsunami [8] or otherwise. We designed a stochastic simulation model based on the empirical distributions, carefully drawn from statistical analysis of the real Freight Data, in an ExtendSim9 environment. The lengthy mathematical derivations and statistical details and its design features are out of the scope of this paper (coded into the equation blocks within the model itself) but may be requested from the funding agency.

The Port Disruption Simulator designed as part of this study provides the port authorities and state's policy makers with reliable estimates in TEUs and monetary measures of the loss due to a disruptive event at the SPB ports during the next decade. Furthermore, the Simulator is capable of producing estimates of losses under various scenarios. Aggregate data on volume (tonnage) and value of containerized cargo in various forms, figures, and tables in the last decade have been used. Various reports and articles have pointed out the significance of the use of inland ports and hubs as transshipment node (facility) in the supply chain network. However, these reports lack full mitigation alternatives. Freight data in aggregate forms have been maintained across multiple platforms at private, state, and federal agencies. However, none is in a suitable form for use with a general modeling of the ports freight flow operations and hence, an area requiring attention.

A resilience measure that is known to minimize the ports shutdown impact is the use of intermediate distribution hubs, often referred to as Inland Ports, such as those at Victorville and Inland Empire in Los Angeles area. These hubs are used as intermediate transshipment nodes in the existing supply chain network and have been found feasible and often near optimal strategy by several other related studies [6]. The primary goal of this research is to increase the effectiveness of the supply chain network and understand the impact of catastrophic events on intermodal cargo throughput through the SPB ports. The complexity and dynamic nature of a supply chain network makes the underlying model amenable to such approaches as simulation and/or optimization techniques or both. It is well know that such problems are suited to cast as stochastic network optimization in which dynamic aspects of flow (movement of cargo) through the network is managed.

This type of research is still in its infancy and a lot more has to be done in preparations for dealing with catastrophic events, which have severe economic impact on California and its southern residents, as well as the national economy. In fact, these studies have only reinforced the importance of recognizing economic resilience in economic impact analysis.

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