National Center for Sustainable Transportation

RESEARCH BRIEF

Efficient Empty Container Movement Considering the Next Day's Demand Can Reduce Port Congestion

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Research Question

International trade continues to grow, increasing container traffic at seaports worldwide. This is especially true at the Ports of Los Angeles and Long Beach, America's busiest ports. The Port of Los Angeles saw a 20% increase in throughput from 2010-2018. Typically, loaded containers arriving at the ports are transported by truck to inland importers, emptied, and then returned to the port. The empty containers are then driven to inland exporters to be loaded and returned to the port for shipping (Figure 1). This lack of direct container exchange between importers and exporters, known as the empty container reuse problem, adds many truck trips to Southern California highways and adds significant expenses for shipping companies. Trucks transporting empty containers contribute to traffic congestion, greenhouse gas emissions, and local air pollution.

Moving empty containers more efficiently could significantly reduce truck trips and the associated congestion and pollution. If the percentage of empty containers exchanged between importers and exporters without traveling back through the port could be increased from the current 2% to just 5% at the Ports of Los Angeles and Long Beach, 950 truck trips a day and 350,000 per year would be eliminated (Figure 2). Previous research has modeled this more efficient container movement during a single day to meet demand while minimizing truck travel. However, the distribution of containers at the end of one day becomes the starting point for meeting the next day's demand. Additional benefits could be gained by considering the day ahead in a route optimization model.

Researchers at the University of Southern California developed an optimization-based vehicle scheduling model that allows for a "street exchange" in which empty containers can go directly from importers to exporters without returning to the port. The model satisfies the current day's known, or deterministic, demand while also accounting for the next day's unpredictable, or stochastic, demand. The model is solved iteratively each day using this two-day time horizon to provide a routing plan for the current day's demand. The model was tested using container demand data from the Ports of Los Angeles and Long Beach as well as randomly generated data sets.

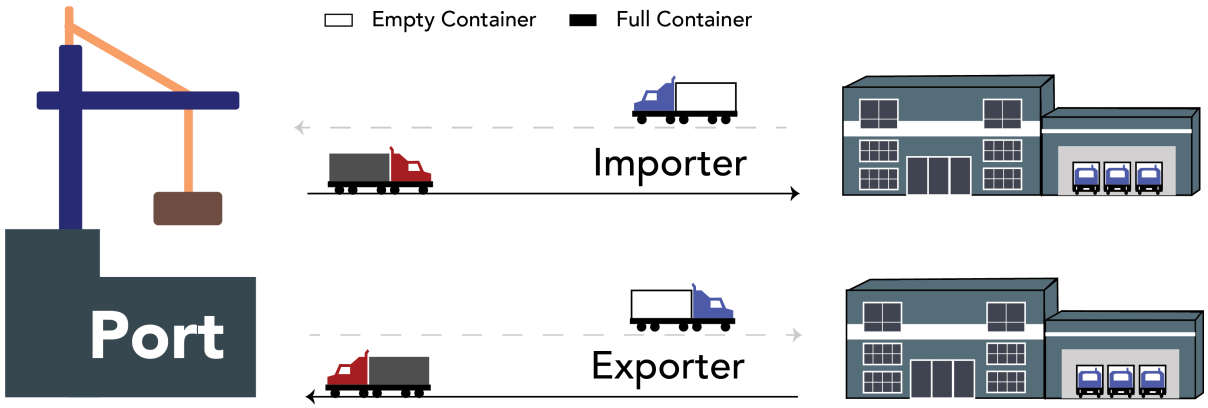

Figure 1. Schematic of current, inefficient container movement.

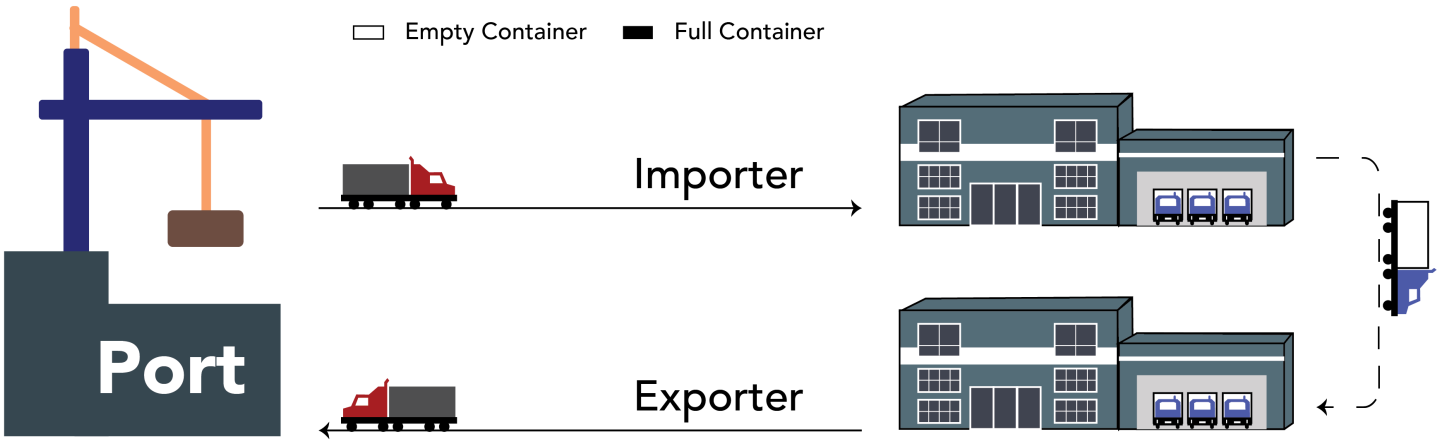

Figure 2. Schematic of efficient container movement with empty container exchanges between importers and exporters.

Key Research Findings

Accounting for the next day's container demand can reduce truck trips. The stochastic model accounting for the next day's container demand outperformed the one-day-at-a-time, or deterministic, model in both randomized experiments and simulations using data from the Ports of Los Angeles and Long Beach. The stochastic model generally resulted in 4-7% fewer truck miles.

The stochastic model leads to more variation in performance than the deterministic model. The stochastic model makes pre-emptive movements to try to minimize the next day's container movements. Because the next day's demand is uncertain, some of these movements will pay off and others will not. This results in greater day-to-day variability in performance, even as the model improves the system's overall efficiency.

As predictions for next-day conditions improve, the solution will improve as well. The stochastic model relies on predictions of the next day's container movements. If better historical data can improve these predictions, more of the pre-emptive container movements will pay off and result in even greater reductions in truck miles.

The use of double container trailers can also increase system efficiency. Double container trailers, which are currently prohibited around the Ports of Los Angeles and Long Beach, extend the number of possible routes between exporters, importers, and the ports. Allowing these larger trailers into the ports could further reduce truck miles traveled.

More Information

This research brief is drawn from "Congestion Reduction through Efficient Empty Container Movement under Stochastic Demand," a report from the National Center for Sustainable Transportation, authored by Maged Dessouky, Santiago Carvajal, and Siyuan Yao of the University of Southern California. The full report can be found on the NCST website at https://ncst.ucdavis.edu/project/congestion-reduction-through-efficient-container-movement-under-stochastic-demand.

For more information about the findings presented in this brief, please contact Maged Dessouky at maged@usc.edu.

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