UCDAVIS
INSTITUTE OF TRANSPORTATION STUDIES &
POLICY INSTITUTE FOR ENERGY, ENVIRONMENT AND THE ECONOMY

ISSUE PAPER
November 2018

Environmental Regulation Impacts on Freight Diversion

Authors: Sam J. Fuller, Kelly L. Fleming, Austin L. Brown

Contributors: Daniel Sperling, Colin W. Murphy

RESEARCH QUESTION

What is the potential effect of environmental policy on freight diversion away from California ports?

Specifically: What does the literature say regarding the real-world impacts of regulations on the way freight is transported? What are the tipping points where regulatory costs could cause some freight transport that would normally come to, through, or out of California to be diverted to other modes and/or to ports outside of the state, and what would be the net change in greenhouse gas (GHG) emissions? What is known about this issue as it pertains to goods transported through ports via maritime shipping, primarily bulk and auto transport vessels?

This whitepaper surveys and summarizes the relevant literature regarding freight diversion. It concludes with recommendations for research to better understand the factors that affect how and where shipping companies transport freight, and to inform development of regulations and policies that can achieve environmental goals while minimizing adverse economic impacts.

SUMMARY

The purpose of this whitepaper is to summarize research regarding how much freight might be diverted from California ports if port costs increase due to policy, especially environmental regulations. Although no publicly available study that examines the precise research question was identified, there is scientific literature examining freight diversion in response to generalized increases in costs. Findings suggest that freight diversion is unlikely to be a major consequence if California imposes port requirements designed to reduce greenhouse gas (GHG) emissions from maritime shipping, if such requirements result in modest cost increases (around $30/TEU[1] or below) for shipping companies. However, this statement is based on studies of port demand elasticity that have not been recently updated.

The potential diversion effect of proposed environmental policies should be examined on the basis of costs (in terms of dollars per TEU) and elasticities of demand for specific ports. Future research could update elasticities (which have been observed to change over time) and address the specific question more directly.

BACKGROUND

Large freight maritime shipping is one of the fastest-growing and largest components of the international economy, carrying almost 90% of all international trade (ICS 2018). California plays a large role in maritime shipping: the ports of Long Beach and Los Angeles are the busiest ports in the United States. Ships are the largest source of emissions in The Los Angeles and Long Beach ports, as opposed to the ground transportation and machinery in the ports (Clean Air Action Plan). The $500 billion maritime shipping industry is a major driver of international economic growth and prosperity, but also of greenhouse gas (GHG) emissions (ICS 2018). Maritime shipping today emits 1 billion metric tons of CO2 annually, an amount that comprises nearly 3% of global CO2 emissions and

[1] TEU, or twenty-foot equivalent unit, is a standard metric of containerized freight.

represents a 90% increase in emissions from 1990 levels. As for particulate pollutants, all maritime shipping emits about 15% and 13% of global NOx and SOx, with international shipping comprising almost 87% and 92% of those pollutants from shipping (IMO 2014). Finally, the International Maritime Organization (IMO) suggests that CO2 emissions from maritime shipping could increase anywhere between 50-250% by 2050 depending on future economic and energy developments (IMO 2014).

Both short- and long-run measures for reducing GHG emissions from maritime shipping are widely available and are being considered by many regulatory agencies and governments. Options range from reducing cruising speeds to using onshore renewable energy to power ships while berthed (in the short run) and transitioning to biofuel and onboard renewable energy for ship power and propulsion (in the long-run). Solutions for reducing emissions from maritime shipping tend to be relatively low cost compared to other industries because many solutions for maritime shipping lead to higher fuel efficiency. Such solutions may require up-front investment but decrease long-term costs, and are therefore cost effective (IMO 2009). A report by the IMO found that CO2 emissions from maritime shipping could be reduced 75% by implementing existing measures and technologies for improving operational efficiency. Another study found that 30–50% of measures examined are cost-effective (Eide et al. 2009). Given maritime shipping's growing environmental and economic impacts, research efforts into both new approaches and how to best implement existing solutions are well under way.

MARITIME SHIPPING THROUGH CALIFORNIA PORTS

California is the largest trade gateway for imports and exports in the United States, with over 16 million containers flowing through the state's 11 commercial ports every year. The ports of Los Angeles and Long Beach are the two busiest ports in the United States. The economic impacts of this maritime trade are large and wide-reaching. An estimated one-third of California's economy (around $700 billion) relies at least in part on the state's commercial ports (CAPA).

California's ports have performed markedly better than other ports in the nation on environmental regulation and overall environmental quality. The Port of Los Angeles has the best water quality of any major industrialized port in the world, while also being the busiest in the United States (CAPA). Through partnerships with the California Air Resources Board (CARB), the state's largest ports have achieved around an 80% reduction in emissions of particulate matter, 90% SOX emissions, and 50% in NOX emissions (CAPA). Many of California's ports have implemented environmental regulations or incentives. The ports of Long Beach and Los Angeles offer financial incentives for ships to reduce speeds when in harbor and for ships equipped with newer, more efficient engines or equivalent NOx-reducing technology (Port of Long Beach and The Port of Los Angeles 2017). Six of California's 11 ports require ships to plug into the electrical grid during loading and unloading rather than idling auxiliary engines. Although these advances have reduced emissions of criteria pollutants and GHGs, regulatory agencies and advocacy groups agree that additional action is needed to reduce localized cancer risk and other health impacts, control GHGs that contribute to global climate change, and control criteria pollutants to meet ambient air-quality standards.

FREIGHT DIVERSION

As stated above, there are multiple known and effective policies for reducing criteria pollutants and GHG emissions from maritime shipping. Many of these policies are targeted at and implemented in ports. However, the extent to which such policies could trigger shipping companies to divert freight to alternative ports is not well understood. Improving understanding is key to maximizing policy effectiveness while minimizing adverse economic effects.

It is important to note that freight diversion resulting from additional regulations and fees has rarely been observed at a large scale. [2]

[2] Nigeria is a notable exception due to its unique combination of corruption, economic growth, and availability of alternative ports in neighboring countries. For more on this, see Chikere et al. 2014.

Nevertheless, basic economic theory suggests that if the cost of regulatory compliance is higher than the cost of changing ports, then a company will choose the cheaper option and move. We refer to this as the "regulatory breaking point." The location of the regulatory breaking point for a particular shipping company is largely determined by the company's demand elasticity for a specific port. Demand elasticity can be affected by a myriad of factors, including accessibility of alternative ports, freight origin and destination, available infrastructure at current and alternative ports, companies' differing valuations of short- and long-run costs, likelihood of similar regulations/costs being adopted at an alternative port over time, and so on. Demand elasticity can also depend on whether regulations and fees are imposed on a unilateral rather than a uniform basis (e.g., by one local, state, or national government rather than by multiple governments working cooperatively) (Sheng et al. 2017). If policies increase costs at one port but not neighboring ports, diversion is more likely.

Assessing and quantifying the factors that affect demand elasticity would support models that can project the level of freight diversion that will occur under various regulatory schemes. Unfortunately, the necessary data is difficult to obtain and analyze, and so most researchers have opted to take a more generalized, aggregate approach to determining the additional costs that would induce freight diversion. In other words, they assess the overall cost level that would lead to diversion rather than examining effects specific policies and associated costs. We are not aware of any study that has specifically calculated the interactions of specific proposed environmental policies (and their resulting costs) with port-specific elasticities of demand in order to assess likelihood of freight diversion.

INFRASTRUCTURE

One factor with particular potential to affect likelihood of freight diversion is access to and availability of infrastructure in ports needed to comply with environmental regulations. For example, if companies are required to power their ships through the electrical grid when in harbor or berthed, ports must have appropriate charging infrastructure. If charging infrastructure is unavailable, the cost burden of supplying it could be assumed by the government/regulatory body or by shipping companies.[3,4] If shipping companies assume a greater share of the cost burden, the companies will either divert freight and/or pass on costs to consumers through higher prices for goods. If the government/regulatory body assumes a greater share of the cost burden, freight diversion is less likely but costs will be passed onto taxpayers. Policymakers must decide how to balance these outcomes when determining how to best implement environmental policies.

RESEARCH INSIGHTS

The purpose of this whitepaper is to summarize research on how much freight might be diverted from California ports if costs increase due to environmental regulations and policies. We did not identify any publicly available research that comprehensively addresses this topic. Several studies (Eide et al. 2009, IMO 2009, Moya and Valero 2017, Wiegmans et al. 2008, Winebrake et al. 2008, Winebrake et al. 2012) provide helpful background, but do not directly address the research question. Other studies examined either (1) demand elasticities at California ports and expected effects of port user fees on freight diversion, or (2) effects of regulation and diversion on GHG emissions from maritime shipping.

SHIPPING COST AND DEMAND ELASTICITY

Many factors affect shipping costs. The major cost categories of shipping are operations, maintenance, voyage expenses, capital investment, and cargo handling expenses. The relative magnitudes of these cost categories can vary substantially. Less developed and landlocked countries tend to face higher insurance and transport costs. Voyage expenses depend on, but are not limited to, ship size, age, speed, nation of vessel registration, distance from origin to destination. Fuel costs are particularly significant. Specifically, Stratiotis (2018) finds that fuel costs can be as much as 50–60% of total ship operating costs, with this fraction increasing as fuel prices continue to rise.

[3] Costs could be passed on to shipping companies either directly (i.e., by requiring companies to construct the infrastructure) or indirectly (i.e., through increased port use fees).

[4] Costs could also be assumed by private port operators, but this scenario will be uncommon in California since all but one of the state's major ports are publicly operated.

Shipping cost variability imparts significant variability onto global shipping patterns, including total volumes shipped and which ports are selected. Consider a situation in which a company wishes to ship freight from an origin destination (O) to a country with two major ports, Port A and Port B. Port A imposes environmental regulations that increase docking cost, but is also 200 miles closer to O than Port B. If the company's ship has high operating expenses (for instance, if it is large and old), the cost of diversion from Port A to Port B may exceed the greater docking cost at Port A—i.e., the company exhibits low demand elasticity to port costs. But if the company's ship has low operating expenses, diversion may make financial sense—i.e., the company exhibits high demand elasticity for port costs. Corbett et al. (2006) confirmed this theoretical example with a study of diversion at California ports. They found that a modest increase in port user fees ($30/TEU) would result in minimal diversion from California ports, particularly when voyages to California cost less than voyages to other US West Coast ports. Leachman et al. (2005) also found that a modest increase in port user fees ($60/FEU[5]) would only result in about a 6% decrease in cargo volume processed at the Port of San Pedro Bay, and that the bay is relatively inelastic up until fees of $190/FEU.

Demand elasticity also depends on the particular characteristics of different ports. Corbett et al. noted "a strong preference for California ports...primarily due to the ancillary benefits of these ports (e.g., landside logistics, access to markets, cargo handling capabilities, etc.)." Demand elasticity is lower for ports closer to the end destination of freight, and for ports well served by other modes of transport like rail (Corbett et al. 2006; Leachman 2010). Pairing stronger regulation with infrastructure improvements may therefore help offset diversion, since the benefits of the latter balance the costs of the former (Leachman 2010).

Estimating port demand elasticities based on all of these characteristics, can be is complicated by the notable instability of freight markets and rates (Leachman 2010). The cost of shipping freight from Shanghai to the US West Coast, for instance, rose from $1,372 per 40-foot equivalent unit (FEU) in 2009 to $2,308/FEU in 2010, before dropping back down to $1,667/FEU in 2011 (UNCTD 2016). This instability means that port demand elasticity can change quickly and dramatically. Caution should be used in applying older studies to current situations.

More detail on each of three port demand elasticity studies cited in this section (Corbett et al. 2006, Leachman 2005, Leachman 2010) is provided in the Appendix.

EFFECTS OF DIVERSION ON GREENHOUSE GAS EMISSIONS

Industry-funded research (PMSA 2017) finds that if diversion occurs, it is likely to increase overall GHG emissions from maritime shipping. Researchers interviewed by Policy Institute staff agreed with this finding but also pointed out that this study does not assess the likelihood of diversion given any specific policy. Sheng et al. (2017) compared the effects of unilateral and uniform regulations on GHG emissions from maritime shipping. They found that poorly implemented and/or overly stringent unilateral regulations could increase CO2 emissions due to freight diversion whereas uniform, multilateral regulations always decrease emissions. This conclusion underscores the benefit of collaborative policymaking and implementation across jurisdictions and regulatory agencies. This does not mean that any unilateral action necessarily increases emissions, but rather that uniform policies have a much lower risk of unintended adverse effects. If most or all major ports had similar infrastructure and environmental requirements, diversion would not be an issue because there would be no non-regulated ports to divert to. GHG emissions would likely decrease, and compliance costs could be on average lower because companies would not have to waste time and resources on adhering to multiple sets of regulations. Uniformity in policy is beneficial even if taken on a regional rather than global scale: e.g., across all US West Coast ports or across all California ports. In general, though, the more multilateral and uniform a policy is, the easier compliance is for companies and the less likely freight diversion becomes.

[5] One FEU, or fort-foot equivalent unit, is approximately equal to two FEU. Hence $60/FEU is approximately equal to $30/TEU.

CONCLUSIONS AND FUTURE WORK

The literature on marine regulation impacts indicates that freight diversion is unlikely to be a major consequence if California imposes port requirements designed to reduce greenhouse gas (GHG) emissions from maritime shipping, if such requirements result in modest cost increases (around $30/TEU or below) for shipping companies. However, this statement is based on studies of port demand elasticity that have not been recently updated.

Decision-makers would benefit from requesting new analyses that more accurately reflect demand elasticities for California ports today. Comparing current elasticities to past elasticities would also provide insight on elasticity volatility, like Leachman 2010. If demand elasticities for California ports are shown to be relatively stable over time, environmental policies resulting in higher cost increases for shipping companies may be tolerable. A more conservative approach may be warranted if elasticities are shown to be more volatile, lest future elasticity changes result in greater levels of diversion than would be expected today. High levels of diversion could become problematic from an environmental as well as an economic perspective. If an environmental regulation causes high levels of diversion, it is possible that impacts could be net negative if the environmental consequences of diversion (e.g., increased fuel consumption) that the regulation triggers exceed the environmental benefits that the regulation achieves.

Decision-makers can take two additional steps to minimize the risk and impacts of freight diversion associated with implementation of environmental policies. First, decision-makers can improve infrastructure and/or offer financial incentives to ships that adopt environmentally friendly practices at targeted ports. These actions provide benefits to shipping companies that offset the burdens of complying with new environmental requirements. Second, decision-makers can strive to ensure that environmental regulations are implemented on a uniform, multilateral basis rather than a port-specific, unilateral one. Uniformity across the state of California would be desirable, but uniformity at a broader scale (e.g., across all US West Coast ports) would be even better. The more multilateral and uniform a policy is, the easier compliance is for companies and the less likely freight diversion becomes.

The above conclusions are based on the best research available at this time. Additional data on port use and further research leveraging such data could improve understanding of how and under what conditions freight diversion occurs. This would in turn inform identification of environmental policies most likely to reduce GHG emissions from maritime shipping without causing adverse outcomes.

APPENDIX - SPECIFIC RESEARH FINDINGS ON PORT DEMAND ELASTICITY

Policy Institute staff identified three studies (Corbett et al. 2006, Leachman 2005, Leachman 2010) that use empirical data to calculate demand elasticities for California ports and estimate change in port choice as a function of applied fees. More detail on each of these studies is provided below.

Corbett, James J., James J. Winebrake, Erin Green, (2006) “Cargo on the Move through California: Evaluating Container Fee Impacts on Port Choice.”

Funded by: Natural Resources Defense Council and Coalition for Clean Air

Key findings: This study assesses whether freight diversion is likely to occur if port user fees (PUFs) are assessed at California ports. These proposed PUFs would amount to about 30$/TEU and would only increase total voyage costs by 1.5%. Furthermore, the study finds that shippers have a strong preference for CA ports, which would lead to less than 1.5% of voyages diverting (this preference makes demand relatively inelastic). For example, they find that a PUF would have to be 40$/TEU before any voyages to LA or Long Beach ports would divert. Overall, the paper concludes, with conservative estimates, that fees that comprise a small percentage of total costs, like the proposed PUFs, would not cause significant diversion from California ports.

Leachman, R.C. (2005). Final Report: Port and Modal Elasticity Study.

Funded by: US Department of Transportation, Southern California Association of Governments

Key Findings: This report analyzes long-run demand elasticity at the San Pedro Bay (SPB) Ports as a function of access fees, determining what fee levels would induce diversion to other ports or transportation modes. It concludes that a $60/FEU fee on inbound loaded containers at the SPB Ports would cut both total import volume and total trans-loaded import volume at the SPB Ports by approximately 6%. It further concludes that with congestion relief, assuring that vessels do not have prohibitively high wait-times, SPB imports are relatively inelastic up to an import fee value of about $200/FEU. This means that significant diversion from SPB would not be expected as long as fees are kept below $200/FEU (approximately equal to $100/TEU).

Leachman, R.C. (2010). Final Report: Port and Modal Elasticity Study, Phase II.

Funded by: US Department of Transportation, Southern California Association of Governments

Key Findings: This report updates many of the datasets and methods used in Phase I (above). It finds that demand elasticity at SPB increased markedly compared to the Phase I analysis due to "unfavorable evolutions in rail intermodal rates and dray costs" (i.e. the costs of shipping by rail from and draying in the CA ports increased significantly). The report emphasizes that this change "provide[s] a cautionary lesson that elasticity of imports can change markedly in the span of only several years, suggesting the need for continuing analysis to keep up with the dynamics of industry and global economics." The fact that demand elasticity can change so much and so quickly means that even if a regulation or fee does not initially have significant consequences, it could cause diversion if other factors (such as changes in intermodal rail costs and availability) shift. Similarly, a regulation or fee could cause initial diversion that decreases later on.

DISCLAIMER

This white paper was developed by the Policy Institute for Energy, Environment, and the Economy (Policy Institute) at UC Davis in response to a request for a specific topical research summary from the California Air Resources Board. In preparing this document, Policy Institute staff corresponded with several experts in the research community to identify key studies and additional experts in the field for consultation. This white paper has not gone through peer review and should be viewed as an informal summary of published research.

ACKNOWLEDGEMENTS

This study was made possible in part through funding received by the University of California from the State of California through the Public Transportation Account and the Road Repair and Accountability Act of 2017 (Senate Bill 1). The authors would like to thank the State of California for its support of university-based research, and especially for the funding received for this project. This work was also supported by expert input from Miguel Jaller, UC Davis; James Winebrake, Rochester Institute of Technology; and Robert Leachman, UC Berkeley.

ABOUT THE POLICY INSTITUTE FOR ENERGY, ENVIRONMENT, AND THE ECONOMY

The UC Davis Policy Institute for Energy, Environment, and the Economy (Policy Institute) leverages world-class university expertise and engages directly with decision-makers to deliver credible, relevant, and timely information and analysis to inform better energy and environmental policy. One of the roles of the Policy Institute is to work with experts summarize best-available research in the form of a white paper in response to requests from California state government.

REFERENCES

LITERATURE

California Association of Port Authorities, (2018) Economic Benefits and Advocacy,http://californiaports.org/economic-benefits.

Chikere, Chigozie A., Calistus C. Ibe, Mobolaji S. Stephens, Obiageli N. Nze, and Wilfred I. Ukpere, (2014) "Motivating Factors for Cargo Diversion from Nigerian Ports to Neighbouring Ports," Journal of Economics 5:1, 77–86.

Corbett, James J., Eric Deans, Jordan Silberman, Erica Morehouse, Elena Craft, and Marcelo Norsworthy, (2012) "Panama Canal Expansion: Emission Changes from Possible US West Coast Modal Shift," Carbon Management, 3:6, 569–588, DOI: 10.4155/cmt.12.65

Corbett, James J., James J. Winebrake, and Erin Green, (2006) "Cargo on the Move through California: Evaluating Container Fee Impacts on Port Choice," https://www.nrdc.org/sites/default/files/air_06081401a.pdf.

Eide, Magnus S., Øyvind Endresen, Rolf Skjong, Tore Longva, and Sverre Alvik, (2009) "Cost-effectiveness assessment of CO2 reducing measures in shipping," Maritime Policy & Management 36:4, 367–384.

International Chamber of Shipping, "Key Facts of Maritime Shipping," http://www.ics-shipping.org/shipping-facts/key-facts.

International Maritime Organization, (2009) "Second IMO GHG Study," http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/SecondIMOGHGStudy2009.pdf.

International Maritime Organization, (2014) "Third IMO GHG Study," http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf.

Leachman, Robert C., (2005) "Final Report: Port and Modal Elasticity Study," http://www.freightworks.org/Documents/Port%20and%20Modal%20Elasticity%20Study.pdf.

Leachman, Robert C., (2010) "Final Report: Port and Modal Elasticity Study, Phase II," http://www.freightworks.org/DocumentLibrary/Port%20and%20Modal%20Elasticity%20Study%20Phase%20II%20-%20Final%20Report.pdf.

Leard, Benjamin, Joshua Linn, Virigina McConnel, and William Rach, (2015) "Fuel Costs, Economic Activity, and the Rebound Effect for Heavy-Duty Trucks. "

Martínez Moya, Julián and María Feo Valero, (2017) "Port Choice in Container Market: A Literature Review," Transport Reviews, 37:3, 300–321, DOI: 10.1080/01441647.2016.1231233.

Midshipman William Murray, (2015) "Economies of Scale in Container Ship Costs," United States Kings Point Merchant Marine Academy, https://www.usmma.edu/sites/usmma.edu/files/docs/CMA%20Paper%20Murray%201%20%282%29.pdf.

Pacific Merchant Shipping Association, (2017) "Greenhouse Gas Route Comparison Tool Overview and Description, http://www.pmsaship.com/pdfs/PMSA%20carbon%20comparison%20context%20piece.pdf

Port of Long Beach and Port of Los Angeles, (2017) “San Pedro Bay Ports Clean Air Action Plan,” www.cleanairactionplan.org.

Sheng, Dian, Zhi-Chun Li, Xiaowen Fu, and David Gillen, (2017) “Modeling the Effects of Unilateral and Uniform Emission Regulations under Shipping Company and Port Competition,” Transportation Research Part E: Logistics and Transportation Review 101, 99–114.

Stopford, Martin, (1997) “Maritime Economics, Second Edition,” https://anzaliport.pmo.ir/pso_content/media/digitallibrary/2013/4/book15/15.pdf.

Stratiotis, Elizabeth, (2018) “Fuel Costs in Ocean Shipping,” More Than Shipping. https://www.morethanshipping.com/fuel-costs-ocean-shipping/.

United Nations Conference on Trade and Development [UNCTD], (2017) “Review of Maritime Transport 2017 – Freight Rates and Maritime Transport Costs,” https://unctad.org/en/PublicationChapters/rmt2017ch3_en.pdf.

Wiegmans, Bart W., Anthony Van Der Hoest, and Theo E. Notteboom, (2008) “Port and Terminal Selection by Deep-Sea Container Operators,” Maritime Policy & Management, 35:6, 517–534, DOI: 10.1080/03088830802469329.

Winebrake, James J., James J. Corbett, Aaron Falzarano, J. Scott Hawker, Karl Korfmacher, Sai Ketha, and Steve Zilora, (2008) “Assessing Energy, Environmental, and Economic Tradeoffs in Intermodal Freight Transportation,” Journal of the Air & Waste Management Association, 58:8, 1004–1013, DOI: 10.3155/1047-3289.58.8.1004.

EXPERT INTERVIEWS

Miguel Jaller, Assistant Professor of Civil and Environmental Engineering at UC Davis

James Winebrake, Dean of Liberal Arts and former Chair of the Department of Science, Technology and Society/

Public Policy at Rochester Institute of Technology

Robert Leachman, Professor of Industrial Engineering and Operations Research at UC Berkeley