PI-0424 Global Trade and Inland Ports

Requested by
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Executive Summary

Background

To maximize the benefits from international trade, a state must have a system that efficiently moves both imported goods to internal customers and exports to external markets. This is where inland ports, also known as dry ports, fill a vital role in facilitating California's bustling economy. These locations serve as intermodal middlemen between seaports and inland warehouse clusters where goods are stored during breaks in movement up and down the industrial supply chain. It is therefore important to understand how recent changes in the interconnected global trade network can impact the continued economic viability of California's dry ports and how Caltrans can best assist the continued success of these vital locations.

This report will be organized into three main sections. The first section presents a detailed analysis of recent trends in global trade, freight and goods movement. The second section examines three topics: the effects of global trade developments on California's inland ports, the value these ports add to global supply chains, and potential policies to support their continued growth and success. The final section provides a list of sources that a reader might want to review for more information. This section includes both documents analyzed in the body as well as other reviewed papers and information not included that could still prove informative.

Summary of Findings

The findings of this preliminary investigation can be broken down into a few key insights:

- Global trade is undergoing a significant period of geopolitical realignment and nearshoring that will have meaningful impacts on California's inland port utilization and infrastructure.
- Due to the lack of specific studies performed on the intersecting impacts of increased renewable energy demand on California's inland ports, the link between green energy utilization and California's inland ports would be a good area for research and potential further study.
- There are a number of policy solutions that could assist California's inland ports in both becoming greener and more efficient over time while also enhancing the state's competitive edge in logistics and goods movement.

Gaps in Findings

Recent Academic or Professional Studies

There do not appear to be many academic studies that provide up-to-the-month information on global trade events in 2026 and their cumulative systemic impacts. Due to research lag time, it is reasonable to assume that we will lack comprehensive reports on 2026 global trade trends and outcomes until well into 2027.

Impact of green energy markets on inland port demand

There is a lack of academic studies that directly examine the impact of green energy markets on inland port demand, especially with a focus on California and its inland ports. Although this information can be inferred from renewable infrastructure import sources and is analyzed later in the document, a specific study or set of studies on this topic could not be found.

O-D pair data for goods transport

There do not appear to be many readily available sources for fine grain origin-destination pair (OD) data for goods transport with a focus on California and its inland ports. Although the paper (Jallar et al. 2018) can provide some guidance on where one might inquire to obtain this information and is examined later in this document.

Next Steps

Readers that are interested in searching for information in the gaps in findings should revisit some of the data sources mentioned as they are frequently updated and might contain data on their period of interest, provided that a reporting lag of approximately six months is acceptable.

Detailed Findings

Shifts in Global Trade Patterns (General)

The world has seen multiple shocks to global trade over the last few years (2020 to 2026), primarily due to the consequences of the COVID-19 pandemic. Though several other events have also taken place and will be addressed later in this document. These historic situations have dramatically altered the landscape of supply chain and goods movement in ways that are still driving shifts in international commerce today.

International Realignment and Global Trade:

A primary consequence of the pandemic's impact on the global supply chain is the accelerating tendency of nations to realign themselves away from historic trade partnerships to create new trade alliances and multinational power blocs. This trend involves countries shifting away from those partners that have a lower level of geopolitical closeness and toward those nations that are better aligned to their values. By extension, it would be assumed that these closer neighbors would be friendlier and more cooperative toward the primary nation on international matters, including trade. For context, in political science geopolitical closeness (or geopolitical proximity) refers to the degree of political, ideological, and strategic alignment between sovereign states (Seong et al. 2025).

Consequently, this international realignment has also resulted in the accelerated adoption of "nearshoring". This is the term for when a nation redesigns its global supply chains to concentrate on locations that are both geographically closer and politically friendlier while simultaneously reducing exposure to long distance supply chain risks brought about by pandemics or other disasters. While nearshoring is becoming more prevalent, this is not to say that all countries have adopted this process equally. Notably, the United States has maintained more trade connections across a broader range of partners regardless of political or social differences for most commercial good markets as compared to other nations (Seong et al. 2025). This relative ambivalence demonstrated in the US trade partner diversification strategy serves to hedge against sporadic instances of global instability that may lower cooperation among otherwise historic partners (Yilmazkuday 2026). We can also expect California's inland ports to receive additional pressure from freight flows due to nearshoring efforts in the future (Snape 2026), though a full analysis is outside the scope of this document.

However, this ambivalence is not absolute, as we do still see a pronounced trade realignment effect when examining strategic resources as well as those that are related to advanced technology and technological innovation. These categories are currently seeing a higher degree of influence based on geopolitical sensitivity and the resultant nearshoring efforts than less critical resource categories (Seong et al. 2025) (Airaudo, de Soyres, Fisgin, Gaillard, Richards, Santacreu, Young 2025).

A relevant, modern example of this phenomenon is how the United States and China have looked to reduce interdependence on one another in favor of strengthening ties to countries and trading blocs. In this case the US has been increasing trade with European partners (The White House 2025) (Directorate-General 2025) and other geopolitically proximate Asian countries. Correspondingly, China has been developing its connection to Russia and other BRICS (Brazil, Russia, India, China and South Africa) members (Singh 2023). This uncoupling is in part responsible for increased global tensions as countries that lack a level of geopolitical closeness are less incentivized to cooperate or temper adversarial viewpoints due to reduced inter-reliance

on each other as an important trade partner (Seong et al. 2025). This implies a cycle of higher global volatility over time that feeds into further nearshoring efforts which incentivizes a reduction in partner diversification for all parties.

What this means from a practical perspective is that the on-paper trading partner diversification and systemic global decoupling that is observed might not be as concrete as what documents may purport (Antras, Kulesza, Presbitero 2026). In fact, the opposite may be true. For the United States and California, the insertion of unofficial trade intermediaries such as those found in ASEAN could have actually led to increased concentration and reliance on China for goods while at the same time providing a dangerous illusion of diversification that could prove costly in the long run for all groups involved (Prometeia 2026).

The Rise of New Multinational Trading Blocs

A secondary consequence of this realignment is the recent creation of new international trade groups formed through collaboration between geographically close neighbors. Most relevant to California and its freight economics are those centered around our partners in the pacific as well as Central and South America. For the sake of brevity this document will focus only on new major trading blocs in this area.

Regional Comprehensive Economic Partnership

Signed in 2020 and active as of 2022, (Cimino-Isaacs, Dolven, Sutherland 2022) the Regional Comprehensive Economic Partnership bloc is an association of Pacific nations, including China and Australia, which was formed with the intent to lower trade costs and bolster cooperation between partner states. This partnership began with the aim to streamline and reduce friction within and between regional supply chains and global supply chains that pass-through partner countries that includes a steep reduction in tariffs and quotas. China's participation specifically is heavily driven by a response to the imposed United States tariffs over the last few years. This development is particularly notable as it has established the largest regional trade bloc in the world (Cimino-Isaacs et al. 2022). While this might have an impact on California's trade volume with Pacific partners it may ultimately prove unimpactful, depending on what these nations import and export to California's ports.

It's important to reiterate that these trade blocs may also serve to mask direct trade with US and China. In other words, this separation might serve to obfuscate the real level of existing dependence rather than represent an elimination of said dependence between the two nations. Given the relative newness of the arrangement, this is only one possible outcome that may result from this development. Future trade data would be helpful in determining the extent of these links, but such analysis is outside the scope of this document.

United States Mexico Canada Agreement (USMCA)

In 2018 the United States federal government undertook a historic effort to revise US trade policy that has been shaped by the North American Free Trade Agreement (NAFTA) since its inception in 1992 (with an effective date of implementation of 1994). This took the form of a new comprehensive international agreement that sought to right perceived wrongs and language that disadvantaged the United States in NAFTA (Chatzky, McBride, Aly Sergi 2020).

This new trade paradigm makes several key revisions which include changes to enhance laws covering fair labor standards as well as impose stricter requirements for "made in place" classifications for automotive industries. Several changes to intellectual property protections in participating countries were also included in the document. (Burfisher, Lambert and Matheson 2019) reviews the legislation and examines efficiency and economic welfare gains and losses

that have occurred as compared to the preexisting NAFTA trade agreement. The article found that, as of 2019 when this paper was published, the overall effect of implementing the USMCA was on the whole neutral with modest increases to net economic welfare of participants of around 500 million, mostly drug down by the impact of steel and other tariffs imposed by the United States. The authors also found that, should the tariffs be eliminated, the economic welfare gains for all parties would increase to approximately $2.5 billion. As of 2026 the situation has changed as the United States has opted to decrease, but not fully eliminate, said tariffs which has likely led to the realization of these increased benefits ("Further adjusting the tariff regimes for imports" 2026).

The full text of the USMCA document is included in the link in the bibliography on page 20 along with the link to the full text of NAFTA to provide for easy comparison between the two for any interested readers wanting to analyze the full text of each piece of legislation.

Economic Analysis of California's Inland Ports

This increased consolidation of trade partners helps to emphasize the importance of inland ports as vital gateways of trade for California and the United States' physically and/or socio-economically close trading partners such as Mexico, Canada and Japan. This is particularly relevant as goods produced in the interior of California with distribution destinations outside the state's borders must first be consolidated and routed correctly in their respective supply chains.

Port Impact

As nearshoring is becoming more prevalent across the global landscape, this can lead, either directly or indirectly, to changes in domestic seaport activity. This can subsequently impact inland dry ports further along in the network. Take for example the ports of Los Angeles and Long Beach which together comprise the single largest freight gateway in the United States and are the primary entry points for international cargo moving into California. As such, these locations can serve as a good proxy for freight flows to inland ports as activity at these coastal hubs directly correlates with overall product movement as goods disperse through the state's logistics network. Interestingly, when analyzing drayage trucking and Twenty Foot Equivalent Unit (TEU) import and export movements in the port, 2024 activity spikes at these ports might indicate a long tail "bullwhip effect" on the supply chain as a result of the COVID 19 disruptions. For reference, the bullwhip effect is what occurs "when retailers order more based on slight increases in demand, which causes each entity in the supply chain to request or produce more in anticipation of higher demand" (Reiff 2026).

A review of data covering drayage truck activity for the Port of Long Beach combined with inflow and outflows of TEUs from 2019–2024 aligns with this assessment as there are corresponding spikes in activity for both categories. This suggests that this elevated truck movements and port throughput in 2024 is consistent with the supply chain's continuing effort to normalize itself after incurring this series of shocks in the early 2020's. This is important as these shifts likely generated increased activity at inland ports and distribution hubs downstream of the ports.

For more recent aggregate information on freight movements, readers might find the source (California Trade Reports 2026) by the California Center for Jobs and the Economy useful as it provides an aggregate overview of some important trade import and export metrics on a rolling monthly basis. As this is a general overview the reader is encouraged to review the data sources and perform their own analysis for more granular information.

Emerging markets:

While there is research on both emerging energy markets and on demand for inland ports, there appears to be a lack of studies that examine the intersection of these fields directly. However, the green energy market's impacts can be estimated and inferred by examining the current and forecasted levels of imports of both finished and in process green energy generation products such as materials for the installation of solar panels, windmill turbines and battery storage. The documents below provide information on power generation, green energy use, growth, imports and forecasts from industry providers that can be used to infer inland port demand due to increased reliance on green energy, though the sources might not be entirely focused on California.

("Renewable Energy", 2025) provides a general breakdown of California's power generation through 2024 including total mix of renewable and nonrenewable sources, energy storage as well as other statistics. While not updated since publication, this resource provides a snapshot of energy demand and supply in California for that time period. Additionally, the site also publishes links to related energy use reports that the reader might find useful.

There is also the dashboard from (California Independent System Operator, 2026) that provides an overall read of current and forecasted demand for energy on the power grid as well as CO2 generated during this generation. For reference, CAISO is a non-profit entity that serves as an independent intermediary between California's high voltage generator suppliers and the broader energy market. Additionally, this organization might be a good source for green energy data sources for Caltrans and other state agencies and so might be worth contacting to see if they have current statistics on renewable energy usage. When combined with other sources that outline the percent of energy generated with green sources in the state, the reader can begin to piece together a better picture of the energy landscape. CAISO's website also provides links to several studies that cover various aspects of California's greenhouse gas emissions.

Neutel, Berson, Saltzer, Brandt, Weyant, Orr, Benson (2026) is a recent study produced by researchers at Stanford that provides a model for reaching zero emission goals by 2045. These findings are based on the DECAL model, and show that significant efforts still need to be made to meet California's aggressive decarbonization goals and forecasts the need for substantial investments into existing green technology and infrastructure. Each of these will likely need to have elements imported and transferred through the inland port system to their final destinations. This will likely drive demand for inland port services over time by a substantial but unspecified amount.

While not strictly related to green energy, (Shayan, Nasrin 2026) does provide some insights on how these ports can provide logistical assistance to the United States in furthering its renewable energy and sustainable energy development goals.

Customer Distribution:

The primary customers of Californias' inland ports are broken down into several broad categories that provide a broad overview of California's major industrial and retail sectors that rely on inland ports for their operations (Carr Ramezani 2025).

- Agriculture, including grain, produce and livestock products
- Manufacturing
- Large retailers such as Target, Walmart and Amazon who rely on these intermediaries as a node to move goods to their final locations.

- Shipping lines
- Rail Freight operators
- Third-Party logistics firms such as DHL

Additionally, much can be understood about the customers and users by reviewing the plans and documentation from California's inland ports. Some examples of resources include:

- Port of Stockton Strategic Plan Framework (2025)
- The port of West Sacramento website
- The port of Richmond website

This list is not comprehensive and readers are encouraged to review the plans of any ports of interest that lay outside this list.

Critical success factors of inland ports

As with most questions about real estate and business, the primary driver of success is location. When intelligently planned and strategically located, inland ports can be a major factor in determining the economic success of a region. By extension this desirability will lead to an outsized level of demand and success as compared to those located in suboptimal locations as the location becomes a highly useful node in the dry port supply chain network (Zhuang, Li, Wu 2023). While the conclusion may appear obvious, the question of determining *where* the optimal location would be is a much tougher question.

Available Data Sources for Recent Freight Metrics

As research papers take time to go from inception to completion this introduces an unavoidable lag between the studies analyzing a situation and what the reality of the current situation is. This discrepancy creates difficulties when trying to find information and analysis on recent events. This oftentimes requires the user to delve into data sources and perform the analysis themselves. In order to help facilitate future analyses this document has compiled a set of freight data providers and portals that should aid in these efforts.

US Army Corps of Engineers Institute for Water Resources:

This resource provides data on commercial waterway traffic for the United States (including California and its water accessible inland ports). The data here is much more recent than what you would likely find in a report and can help paint a picture of the movement of freight and activity of water facing inland ports like the port of Sacramento. A link to the website is included in the bibliography later in this document on page 14.

Replica port of Long Beach and Port of LA freight truck data
Another good source of information for Caltrans employees to get reasonably recent information on commercial truck activity is the Replica data platform. They provide commercial truck data on both sea port and inland port activities in California, however their data should be used in conjunction with other truck data sources to derive clearer conclusions. The ports of Long Beach and Los Angeles also frequently publish aggregate goods movement statistics and TEU movement volumes each month which provides a general overview of current downstream transportation and storage pressure that inland ports might see for that period.

Jallar paper on supply chain disruption dashboard
In (Jallar 2024) the research team developed a supply chain disruption dashboard that utilized data analytics and semantic clustering to search social media and other internet articles for information on potential volatility or disruptions on supply chains. This dashboard may provide a useful resource in obtaining freight data and tracking supply chain disruptions for Caltrans employees specifically.

Other:
Another good source is (Neutel et al. 2026) as their research provides direct links and listings to all data sources they used for their development of the model and would be a good starting point for a broader examination of renewable energy demand forecasting to better inform inland port demand models on this matter.

International Energy Agency (IEA) website:
The broader website of the IEA provides some data documents regarding total energy usage and GHG generation with respect to traditional power sources. They may also have additional studies and data to share should one want to reach out and discuss.

How Caltrans Districts Can Help With Economic Competitiveness of CA Inland Ports:

Finally, we have come to the question of actions that Caltrans could take on a policy level to help support California's inland ports. As this is a nuanced and complicated topic, it may be beneficial to request a study on policy initiatives for supporting California's inland ports from professional and academic research institutions.

This doesn't mean that useful resources don't exist, they just provide a broader view of the topic that may miss important California specific nuances. The studies (Pratelli, Van Duin, Souleyrette, Bianchini, Marigo, Brocchini and Teng 2021) and (Gillingham and Huang 2020) provide a range of policy recommendations for enhancing operations and adopting best practices of inland port operations. Bergqvist and Monios (2019) is a book dedicated to sustainable operations policies for both sea and inland ports. The publication also presents an analytical framework for discovering and identifying optimal policy practices for inland and sea ports to mitigate the impacts of climate change. Martinez Ferguson, Sharmin, Camur and Li (2025) also dedicate a portion of their research publication to including potential improvements to the practice of intermodal port transportation sustainability.

Sources:

This section provides a list of all sources found that might be of interest to the reader, including many that didn't make it in the body of the text but still might be useful.

Emerging Markets and Trends with a Focus on Renewable Infrastructure

Bergqvist, R., Monios, J.(2019) "Green ports: Inland and Seaside Sustainable Transportation Strategy"
https://books.google.com/books?hl=en&lr=&id=YftUDwAAQBAJ&oi=fnd&pg=PP1&dq=Green+ports:+Inland+and+seaside+sustainable&ots=DtWetSKQgy&sig=hKqAQkLcQufuULiX8KlenBavMSo#v=onepage&q=Green%20ports%3A%20Inland%20and%20seaside%20sustainable&f=false

2019 book published by Elsevier, Inc that goes in depth on the sustainability strategies for sea and inland ports that promote an efficient but environmentally responsible network of ports. This isn't California specific but there is a lot of information here that might be useful as a primer on the subject. The publication discusses a wide range of topics such as structuring incentives for greener inland ports and multiple sections covering the adoption of sustainable technologies in the freight sector with specific focus on how inland ports can assist in the green-ification of shipping and cargo transportation fleets within and between inland ports 0and enhance environmental sustainability overall.

N.A. (2025, December 16). "Renewable Energy". California Green Energy Index. URL: https://greeninnovationindex.org/2025-edition/renewable-energy/

Article provides a general overview of California's power generation mix for renewable sources specifically, as well as numerous data sources that can be pursued if further analysis on the topic is required.

California Independent System Operator (2026) "Today's Outlook"
https://www.caiso.com/todays-outlook/supply

This website shows a breakdown covering the total amount of energy demanded in California at a given point in time. This includes how much is generated by renewable sources exclusively as well as those sources that have a hybrid generation profile. There are also a number of graphs that show how trends in each category have changed over the day as well as the ability for the user to download all the data sets used to generate the graphs to run their own analysis on.

Climate Matters (2026) "U.S. Solar and Wind Growth in 2025" Climate Central.
https://www.climatecentral.org/climate-matters/solar-and-wind-2026

This website provides a number of datasets related to US solar and wind power generation adoption that the reader might find useful

Sharmin, A., Martinez-Ferguson, M., Camur, M. C., & Li, X. (2026). Decarbonizing Freight Through Intermodal Transport: An Operations Research Perspective—Part II: Modal Configurations and Sustainability Pathways. Future Transportation, 6(1), 37.
https://doi.org/10.3390/futuretransp6010037
From the abstract:

"Building upon the methodological synthesis presented in Part I, this second part of our two-part survey examines how operations research (OR) models have been applied to capture the

broader dynamics of intermodal transport (IMT) in pursuit of decarbonization. The analysis integrates chronological, modal, and sustainability-oriented perspectives to reveal how IMT strategies evolve across transportation modes, policy environments, and temporal contexts. We identify how efficiency gains, modal shifts, and low-carbon technologies interact within OR frameworks, and assess their implications for emissions reduction, energy use, and network resilience. By bridging technical modeling approaches with system-level sustainability objectives, this study offers a holistic understanding of the pathways through which OR supports the transition toward low-carbon freight systems and highlights research gaps for future interdisciplinary work."

Fallah Shayan, Niloufar & Mohabbati Kalejahi, Nasrin. (2026). The strategic role of inland ports in advancing the sustainable development goals (SDGs) through logistics and regional development. Discover Sustainability. 7. 10.1007/s43621-026-02835-4

From the abstract:
"Despite growing recognition of inland ports as critical logistics infrastructure, their contributions to the United Nations Sustainable Development Goals (SDGs) remain fragmented and inadequately mapped in academic literature. This study addresses this gap through a structured narrative review of 101 peer-reviewed articles from Web of Science and Scopus (2012–2025) examining inland port sustainability outcomes. We present a novel integrated framework categorizing inland ports' multidimensional impacts into four realized contribution domains: (1) logistics and supply-chain management, (2) sustainable transport and environmental impact, (3) integrated seaport, regional, and urban development, and (4) socio-economic growth and competitive advantage. "

Gillingham, K. and Huang, P. (2020) "Long-Run Environmental and Economic Impacts of Electrifying Waterborne Shipping in the United States";
https://pubs.acs.org/esthag/article/54/16/9824/803438/Long-Run-Environmental-and-Economic-Impacts-of

From the abstract:

"Emissions from ships in and surrounding ports are a major contributor to urban air pollution in coastal and inland riverside cities. Connecting docked ships to onshore grid electricity and using electric tugboats are two approaches to reduce pollution damages. This paper examines the effects of the widespread adoption of electrification in waterborne shipping. Our study is novel in the use of an equilibrium model of the U.S. energy system to capture the effects of increasing electricity generation to electrify waterborne shipping both with and without a carbon pricing policy. We examine three scenarios, Electrifying in ports, Electrifying in Emission Control Areas, and Electrifying all U.S. vessel fuels, as well as an electrification scenario under carbon pricing, allowing electrification of waterborne shipping to contribute to deeper decarbonization. We find that electrification results in slight carbon emission reductions in early projected years and that the reductions increase as the electric grid evolves out to 2050. We also show that an ambitious scenario of electrifying all U.S. vessel fuels results in up to 65% net reduction in air pollution as we approach 2050, even after accounting for the pollution increase from grid generation. Our baseline results indicate that intensive waterborne shipping electrification can provide considerable social benefits that exceed the costs, especially as the electric grid decarbonizes."

Kurtuluş, E. (2023). Optimizing inland container logistics and dry port location-allocation from an environmental perspective. Research in Transportation Business & Management, 48, 100839. https://doi.org/10.1016/j.rtbm.2022.100839

From the abstract:

“This study aimed to optimize inland container logistics with dry port location-allocation by including empty container relocation and volume discounts. A multi-objective mixed-integer programming model was proposed and implemented to optimize total costs and total emissions. The results showed that the total emissions can only be minimized down to 13.23% lower than the amount created from the minimum costs. This indicates that modal shift should not be seen as a miracle solution for emissions reduction instead it should be seen as a first step before the adaptation of high energy-efficient rail transportation technologies. Decreasing rail transportation costs came forward as the most effective measure for emission reduction. The results also revealed the importance of providing enough capacity in the railways for achieving low emissions. In the application case, the electrification of railways would not achieve much decrease in emissions. Additionally, it was shown that possible environmental taxation of road transportation would significantly increase total costs while making almost no impact on emissions.”

Martinez Ferguson, M., Sharmin, A., Camur, M. C., & Li, X. (2025). A review on intermodal transportation and decarbonization: An operations research perspective (arXiv:2503.12322) [Preprint]. arXiv. https://arxiv.org/abs/2503.12322

From the abstract:

“This paper reviews intermodal transportation systems and their role in decarbonizing freight networks from an operations research perspective, analyzing over a decade of studies (2010-2024). We present a chronological analysis of the literature, illustrating how the field evolved over time while highlighting the emergence of new research avenues. We observe a significant increase in research addressing decarbonization since 2018, driven by regulatory pressures and technological advancements. Our integrated analysis is organized around three themes: a) modality, b) sustainability, and c) solution techniques. Key recommendations include the development of multistage stochastic models to better manage uncertainties and disruptions within intermodal transportation systems. Further research could leverage innovative technologies like machine learning and blockchain to improve decision-making and resource use through stakeholder collaboration. Life cycle assessment models are also suggested to better understand emissions across transportation stages and support the transition to alternative energy sources.”

N.A (2026) “Solar & Storage Supply Chain Dashboard”. Solar Energy Industries Association URL: https://seia.org/research-resources/solar-storage-supply-chain-dashboard/

Website provides a snapshot in time of various aspects of United States’ solar power generation and storage infrastructure and accompanying statistics. The website also provides an overview of the solar energy supply chain as it’s being installed across the united states.

Neutel, J. Berson, A. Saltzer, S. Brandt, A. Weyant, J. Orr Jr., F. Benson, S. (2026) “What will it take to get to net-zero emissions in California?
https://www.sciencedirect.com/science/article/pii/S0301421525003556

From the abstract:

“In this work, a new modeling tool called DECAL (DEcarbonize CALifornia) is developed and used to evaluate what it will take to reach California's climate mandate of net-zero emissions by

2045. DECAL is a scenario-based model that projects emissions, society-wide costs, and resource consumption in response to user-defined inputs. DECAL has sufficient detail to model true net-zero pathways and reveal fine-grain technology insights."

Zhang, L., Liu, Q., Mathisen, T. A., & Ge, Y. E. (2026). Navigating environmental sustainability in inland waterway transport: emission challenges and solutions. *Maritime Policy & Management*, *53*(4), 625–649. https://doi.org/10.1080/03088839.2025.2523589 https://www.tandfonline.com/doi/full/10.1080/03088839.2025.2523589

From the abstract:

"Emissions from inland waterway transport (IWT) have a significantly higher local impact than those from ocean-going shipping, yet have not been equally studied. This paper reviews the key research topics in IWT environmental emission studies since 2000, highlighting the current challenges and the future prospects. The findings reveal that existing models for estimating IWT emissions require significant improvement, and government and industry measures to mitigate IWT emissions are still insufficient. In particular, the lack of financial incentives and comprehensive economic analyses hinders the widespread adoption of emission reduction strategies. Addressing these issues is crucial for promoting the environmental sustainability of IWT."

General CA Imports, Exports, and Trade

California Trade Reports: https://centerforjobs.org/ca/trade-reports

Source provides monthly updates on California's trade statistics that can help provide a general picture of current trends over time that formal research papers might not have looked at due to recency of the data. Information included generally includes dollar value of total trade moving through CA ports, in real and nominal values with the real value pegged to the 2019 value of the dollar. The reports cover the month over month change in exports and imports in billions of dollars so provides a rolling snapshot of trade change overall as well as a list of top 20 imports and exports for the month over the 5 largest California sea ports. Again, sea ports are a good proxy for inland port activity as the majority of cargo received tends to originate at these locations or have moved through them to reach a major sea port for exports or empty cargo containers.

IEA (2024) "Massive global growth of renewables to 2030 is set to match entire power capacity of major economies today, moving world closer to tripling goal". International Energy Agency. https://www.iea.org/news/massive-global-growth-of-renewables-to-2030-is-set-to-match-entire-power-capacity-of-major-economies-today-moving-world-closer-to-tripling-goal

IEA (n.d.) "Data and Statistics" https://www.iea.org/data-and-statistics/data-sets

This page hosts a range of data sets and statistics for a range of IEA models including time series analysis on coal trade, emissions factors, Critical minerals in 2025 and Gas trade flows among many other categories. Many of these sources are free but it should be noted that some are paid so careful assessment should be made prior to purchasing any data set.

IER (2026) "California Turns to Imports as Its Refineries Close". Institute for Energy Research https://www.instituteforenergyresearch.org/fossil-fuels/gas-and-oil/california-turns-to-imports-as-its-refineries-close/

This article covers how California is starting to rely more on direct fuel imports as a direct result of refineries in the state shutting down or moving out of the state. This has direct implications for both sea and inland ports as the majority of trains and freight trucks across the state rely on either gas or diesel for operation. As gasoline and diesel are finished goods for consumption rather than raw consumable goods, they are considerably more expensive than the unrefined oil that would otherwise be made into gasoline at a California refinery. The resultant increase in cost of fuel may have detrimental impacts on freight transportation providers along the supply chain as well as the inland port support system that supports this value chain.

California, State Benefits of Trade: URL: https://ustr.gov/map/state-benefits/ca

This article provides information on the various imports and exports of California. Importantly provides a breakdown of major export hubs in the state of California. This would directly tie to inland ports as they're intermediary hubs for exported goods so might be useful to know in a general sense.

Montoya, D. & Bohn, S. " California's Economy" Public Policy Institute of California https://www.ppic.org/publication/californias-economy/

Again, from the Public Policy Institute of California. Provides a snapshot of California's economy as of May 2026, highlights high rate of growth while not the fastest growing state in the nation over 25 years.

Montoya, David (2026) "California's Trade Landscape Is Shifting, Not Shrinking—So Far" Public Policy Institute of California https://www.ppic.org/blog/californias-trade-landscape-is-shifting-not-shrinking-so-far/

It's important to note that this is a blog post from a think tank based in California called "Public Policy Institute of California" rather than a peer reviewed study or research article. That being said the source appears credible. The article itself discusses recent trade data from the end of 2025 and highlights several key findings. These include how China has been unseated as California's top trading partner by Mexico and how Taiwan has quickly taken the third spot in this category for the year. They also discuss changes in a variety of imports and exports

Geopolitical and Global Trade Dynamics

Antras, P., Kulesza, A. & Presbitero, A. (2026). The Remains of the Trade: The U.S.–China Trade War and its Aftermath.
shttps://antras.scholars.harvard.edu/sites/g/files/omnuum5876/files/2026-03/PAAPAlUla_1.pdf

From the abstract:

"We study how the U.S.–China trade conflict has reshaped global trade patterns and how these changes interact with the rise of geoeconomic rivalry. Using recent tariff policy changes and monthly international trade flow data, we document a large reallocation of imports and exports away from direct U.S.–China links and toward third–country economies. To interpret these third-country outcomes, we introduce a taxonomy that separates various exposure margins – export competition, import exposure, sourcing opportunities, and rerouting potential – and construct simple indices that map countries into these channels. We then show that geopolitical alignment has become increasingly predictive of bilateral trade outcomes, and we develop a framework in which geopolitical influence alters unilateral tariff incentives and the sustainability of cooperative

trade policy. The results help explain recent mounting strains on the rules-based trading system."

Airaudo, F. S., de Soyres, F., Fisgin, E., Gaillard, A., Richards, K., Santacreu, A. M., & Young, H. L. (2025, December 12). *Understanding trade fragmentation* (FEDS Notes). Board of Governors of the Federal Reserve System. https://www.federalreserve.gov/econres/notes/feds-notes/understanding-trade-fragmentation-20251212.html [federalreserve.gov], [ideas.repec.org]

Analysis from the Federal Reserve of the United States regarding various aspects of trade fragmentation and supply chain obfuscation that are discussed earlier in the document. Its an interesting read as a start to understanding the complexities of modern international trade in the 2020's and its dynamic nature.

Burfisher, Mary E. and Lambert, Frederic J. and Matheson, Troy, NAFTA to USMCA: What is Gained? (March 2019). IMF Working Paper No. 19/73, Available at SSRN: https://ssrn.com/abstract=3377474

From the abstract:

"The United States - Mexico - Canada Agreement (USMCA) was signed on November 30, 2018 and aims to replace and modernize the North-American Free Trade Agreement (NAFTA). This paper uses a global, multisector, computable-general-equilibrium model to provide an analytical assessment of five key provisions in the new agreement, including tighter rules of origin in the automotive, textiles and apparel sectors, more liberalized agricultural trade, and other trade facilitation measures. The results show that together these provisions would adversely affect trade in the automotive, textiles and apparel sectors, while generating modest aggregate gains in terms of welfare, mostly driven by improved goods market access, with a negligible effect on real GDP. The welfare benefits from USMCA would be greatly enhanced with the elimination of U.S. tariffs on steel and aluminum imports from Canada and Mexico and the elimination of the Canadian and Mexican import surtaxes imposed after the U.S. tariffs were put in place."

Chatzky, A. McBride, J. Aly Sergi, M. (2020) "*NAFTA and the USMCA: Weighing the Impact of North American Trade"*
https://www.cfr.org/backgrounders/naftas-economic-impact

Provides an overview of the USMCA when it was newly implemented, its relative immediate effects and an exploration of what might occur in North American trade as a result in the coming years.

Cimino-Issacs, C., Dolven, B., Sutherland, M., (2022) "*Regional Comprehensive Economic Partnership (RCEP)*". Congressional Research Service, The United States Congress. https://www.congress.gov/crs-product/IF11891

A fact file produced by the United States Congressional Research Service that explores the various impacts of the newly created Regional Comprehensive Economic Partnership that started in the early 2020's. Examines the issue from a United States perspective including possible threats to US trade interests in the region as a result of this new agreement.

Full text of NAFTA: https://fraser.stlouisfed.org/title/north-american-free-trade-agreement-implementation-act-nafta-1135/fulltext

This link provides a full text searchable copy of the North American Free Trade Agreement that has been replaced by USMCA in July of 2020. This is included in the preliminary investigation sources in order to allow for easy and direct comparison with USMCA for interested parties.

Jallar, M. Harvey, J., Saremi, S., Hanjiro, A., Ali A, B. (2018) “Development of a Freight System Conceptualization and Impact Assessment (Fre-SCANDIA) Framework”. National Center for Sustainable Transportation. URL: https://escholarship.org/uc/item/05g8p7tn

From the abstract:

“The conceptual framework analyzes the freight flows in supply chains, and the type of freight activity movements and modes. The framework uses a Life Cycle Assessment (LCA) Methodology. The framework could be extended to support multidimensional cost/benefit appraisals for both direct benefits (e.g., delays, costs, accidents, maintenance) and social benefits to non-users which include impacts on regional and national economies as well as environmental and health impacts. This report discusses the main components of the conceptual framework based on a comprehensive review of existing methodologies.”

Prometeia (2026) “The Illusion of Decoupling Between Washington and Beijing” https://www.prometeia.com/en/about-us/insights/article/lillusione-del-decoupling-tra-washington-e-pechino-51683484

This article highlights how, despite perceived trade decentralization between the United States and China that these two countries are still reliant on heavy trade with one another. However, this reliance is masked by the fact that the two nations are now working through third party states in the Asian-Pacific region to trade materials rather than the direct line that we have seen previously. The article mentions that this has been in process for some time and is a consequence of a worsening trade war.

Reiff, N. (2026) “Understanding the Bullwhip Effect: Causes and Solutions”. Investopedia. People Inc. URL: https://www.investopedia.com/about-us-5093223

A primer on what is known as the “Bullwhip Effect”. Examines what the issue is, what causes it and how firms might mitigate the impact it has on their operations.

Seong, J. White, O., Birshan, M. Woetzel, L. Lammanna C. Condon, J. Devesa , D. (2025) “Geopolitics and the geometry of global trade: 2025 update” McKinsy Global Institute https://www.mckinsey.com/mgi/our-research/geopolitics-and-the-geometry-of-global-trade-2025-update

This document, produced by the McKinsey Global Institute, provides an overview of the current geopolitical landscape with respect to global trade and international relations. The main finding is that most countries are starting to look toward closer economic partners that are both geographically closer and more politically aligned with the country in question. This has substantial implications for global supply chains and the flow of freight on a multi country scale.

Singh, A. (2023) “BRICS and BRI: China Aims for Strategic Alignment” https://www.orfonline.org/research/brics-and-bri-china-aims-for-strategic-alignment

Article discusses how China has been working with other BRICS countries to expand partnership. This is in part due to recent US trade policy decisions that include tariffs on goods and services being imported to the country. Also discusses how the endgame might be for

China to link BRICS to their current “belt and road” initiative to strengthen themselves economically and lessen their reliance on the United States and their allies for economic prosperity.

Shao, L., Feng, K., Wu, Z., Chen, Z., Ge, J., Chen, G.-Q., Chen, B., Zhang, B., Li, J., & Chen, W.-Q. (2026). Tracing China’s unseen rare earth exports that sustain global consumption. Cell Reports Sustainability, 3(1), 100553. https://doi.org/10.1016/j.crsus.2025.100553

From the abstract:

“While China’s direct exports of concentrated rare earth (RE) materials have been widely recognized, this study shows that a substantial share of RE is also delivered indirectly through global supply chains. By constructing detailed inventories of China’s RE flows and downstream uses, we trace and decompose these indirect exports from 1990 to 2020, revealing China’s critical yet often overlooked role in sustaining international RE supply. The results reveal that over 60% of RE resources extracted in China were exported to other regions during this period, of which approximately 62% were direct exports and 38% were embedded indirectly in traded goods. The overall trade structure has shifted from direct to indirect exports, highlighting the growing role of indirect RE flows. The United States (US), Japan, and Europe emerged as the three main destinations of China’s RE exports. […] We then identify diverse indirect export pathways that play a significant role in sustaining global RE supply. […]These findings underscore the importance of international cooperation—both to leverage indirect RE exports for resilient supply and to jointly pursue measures that mitigate their environmental costs.”

The White House (2025) “Fact Sheet: The United States and European Union Reach Massive Trade Deal” https://www.whitehouse.gov/fact-sheets/2025/07/fact-sheet-the-united-states-and-european-union-reach-massive-trade-deal/

White house press release detailing a new trade deal with Europe and an example of increased ties between the US and Europe in the 2020’s.

Directorate-General for Trade and Economic Security (2025) “Joint Statement on a United States-European Union framework on an agreement on reciprocal, fair and balanced trade”. The European Union. s https://policy.trade.ec.europa.eu/news/joint-statement-united-states-european-union-framework-agreement-reciprocal-fair-and-balanced-trade-2025-08-21_en

The European Union’s press release of the new trade agreement with the US, corollary example of increased ties between the US and Europe to above listing.

The White House 2026 “FURTHER ADJUSTING THE TARIFF REGIMES FOR IMPORTS OF ALUMINUM, STEEL, AND COPPER INTO THE UNITED STATES” https://www.whitehouse.gov/presidential-actions/2026/06/further-adjusting-the-tariff-regimes-for-imports-of-aluminum-steel-and-copper-into-the-united-states/

Press release from the United States White House discussing the lowering of tariffs on aluminum and copper for USMCA partners.

Yilmazkuday, H. (2026) “Geopolitical Tensions and Trade: Mitigating through Partner Diversification” https://www.sciencedirect.com/science/article/abs/pii/S0148619525000426

From the abstract:

“This paper investigates the growing impact of geopolitical tensions on global trade and the mitigating role of trade partner diversification. Adapting a trade model and employing a novel bilateral geopolitical disagreement measure based on trade sanctions, we use comprehensive sectoral trade data covering the period of 1966-2020 to analyze trade flows of 167 countries. Our findings reveal that geopolitical tensions significantly reduce trade across all sectors, whereas trade partner diversification acts as a powerful buffer, offsetting these trade losses. We further identify sector-specific trade partner diversification thresholds, offering actionable insights for policymakers aiming to build more resilient trade networks in an increasingly fragmented global economy.”

Ports, Freight, and Logistics Infrastructure

United States Army Corps of Engineers (N.D.) “Navigation and Civil Works Decision Support”. US Army Corps of Engineers Institute for Water Resources Website https://www.iwr.usace.army.mil/About/Technical-Centers/NDC-Navigation-and-Civil-Works-Decision-Support/

Provides details on commercial waterway traffic for the United States (including California and its water accessible inland ports). The data here is much more recent than what you would likely find in a report and can help paint a picture of the movement of freight and activity of water facing inland ports like the port of Sacramento.

Carr, Chris and Ramezani, Cyrus A., The Prospects for Developing Inland Logistics Ports in California (July 15, 2022). Available at SSRN: https://ssrn.com/abstract=4175841 or http://dx.doi.org/10.2139/ssrn.4175841

From the abstract:

“It is generally accepted that strategically placed and efficiently operated inland ports can result in significant efficiency gains for the U.S. logistics system. The purpose of the present study is to assess the prospects and pinpoint the impediments to the creation of inland facilities suitable to the SPB port complex. In order to accomplish this task, we undertake the following analysis: Identify existing and planned inland ports, including those in neighboring states, their development stage, and their potential role in the SPB logistics infrastructure. Relying on previous feasibility studies and input from the SPB ports’ stakeholders, we catalog the economic and institutional impediments to the development of inland facilities to serve these ports. A large portion of the trade volume moving through the SPB ports consists of containerized agricultural exports. We assess the role of existing and planned inland ports in facilitating the growing U.S. containerized agricultural trade.”

Carr, C. Ramezani, C. (2025) “The Impact of Capacity Investment at Major West Coast Ports and Terminals that Connect to the Movement of Containerized Agricultural Exports - Focusing on the Ports of Los Angeles, Long Beach, Oakland, and Seattle-Tacoma (Northwest Seaport Alliance)”.SSRN. URL https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5095941

This report provides an analysis of existing capacity at west cost shipping nodes and evaluates the investments made by the operators to improve and expand capacity of these locations. The document also explores what additional upgrades still need to be made and makes a case for further intensive federal and state funding for these institutions to help ensure these needs get met.

Cariou, P., & Notteboom, T. (2022). Implications of COVID-19 on the US container port distribution system: import cargo routing by Walmart and Nike. International Journal of Logistics Research and Applications, 26(11), 1536–1555. https://doi.org/10.1080/13675567.2022.2088708

From the abstract:

“The purpose of this paper is to discuss the implications of COVID-19 on container import flows via the US port distribution system. We employ statistics collected for more than 21 US ports and for more than 550,000 container shipments by Walmart and Nike to identify trends and potential shifts in the US port distribution system. Results unveil different changes in distribution channels during the pandemic era, between aggregated port level and industry level. These differences are specific to firms and could be explained by the origin of flows, carrier selection to transport”

Cidell, J. (2025). Pop-up ports and port creep in the logistics city: U.S. East and West Coast ports in the 2021 supply chain crisis. Urban Geography, 47(2), 286–302. https://doi.org/10.1080/02723638.2025.2576414 https://www.tandfonline.com/doi/abs/10.1080/02723638.2025.2576414

From the abstract:

“In the North American supply chain crisis of late 2021, some ships and containers stayed in place too long, while others moved too quickly. Local and federal governments and private actors responded via what they termed “pop-up ports,” either helping to secure port spillover space adjacent to existing logistics facilities, or extending port functions to new spaces as part of the logistics city. While the need for temporary storage to smooth out the frictions of the global logistics system is not new, this terminology and its apparent contrast to urban sites of activation and creativity is noteworthy. This paper considers how the pop-up ports developed in U.S. West and East Coast sites demonstrate the concept of “port creep,” where incremental movements expand ports outward while avoiding major infrastructure investment and environmental review.”

Ducruet, C. & Guerrero, D. (2022) “Inland cities, maritime gateways, and international trade” Journal of Transport Geography, Volume 104, URL: https://www.sciencedirect.com/science/article/pii/S0966692322001569

From the abstract:

“This research focuses on the accessibility of inland cities to maritime trade. A quantitative analysis of 64 inland capital cities situated in coastal countries is proposed based on indicators that relate to ports, transport, trade, and urban factors. The identified trends suggest that there is a trade-off between remoteness from the sea and trade openness, which leads us to postulate the existence of three typologies of inland cities: major logistics hubs, constrained metropolises, and underdeveloped corridors. We conduct a more qualitative review of intermodalism and port choice issues with reference to a selection of six selected case studies. The observed spatial configurations have implications for logistics and governance.”

Gbako S, Paraskevadakis D, Ren J, Wang J, Radmilovic Z (2025), "A systematic literature review of technological developments and challenges for inland waterways freight transport in

intermodal supply chain management". Benchmarking: An International Journal, Vol. 32 No. 1 pp. 398–431, doi: https://doi.org/10.1108/BIJ-03-2023-0164

From the abstract:

“Inland shipping has been extensively recognized as a sustainable, efficient and good alternative to rail and road modes of transportation. In recent years, various authorities and academic researchers have advocated shifting from road to other sustainable modes like inland waterway transport (IWT) or rail transport. Academic work on modernization and technological innovations to enhance the effectiveness and efficiency of waterborne transportation is becoming apparent as a growing body of literature caused by the need to achieve a sustainable transport system. Thus, it became apparent to explore the research trends on IWT.”
“[…] The key findings of this review are that despite various challenges confronting the sector, there have been successful cases of technological advancement in the industry. The main interest among scholars is improving technical and economic performance, digitalisation, and safety and environmental issues. The review revealed that most of the literature is fragmented despite growing interest from practitioners and academic scholars. Academic research to address the strategic objectives, including strengthening competitiveness (shipbuilding, hydrodynamics, incorporating artificial intelligence into the decision-making process, adopting blockchain technology to ensure transparency and security in the transactions, new technologies for fleets adaptation to climate change, more effective handling, maintenance and rehabilitation technologies), matching growth and changing trade patterns (intermodal solutions and new logistics approaches) are major causes of concerns.”

Hossain, N., Nur, F. Jaradat, R., Seyeymohsen, H. Marufuzzaman, M., Puryear, S. Buchanan, R. (2019) “Metrics for Assessing Overall Performance of Inland Waterway Ports: A Bayesian Network Based Approach” Modeling and Quantification of Resilience in Complex Engineering Systems. URL: https://onlinelibrary.wiley.com/doi/full/10.1155/2019/3518705

From the abstract: “Because ports are considered to be the heart of the maritime transportation system, thereby assessing port performance is necessary for a nation’s development and economic success. This study proposes a novel metric, namely, “*port performance index (PPI)*”, to determine the overall performance and utilization of inland waterway ports based on six criteria, *port facility, port availability, port economics, port service, port connectivity, and port environment*. Unlike existing literature, which mainly ranks ports based on quantitative factors, this study utilizes a Bayesian Network (BN) model that focuses on both quantitative and qualitative factors to rank a port. The assessment of inland waterway port performance is further analyzed based on different advanced techniques such as sensitivity analysis and belief propagation. Insights drawn from the study show that all the six criteria are necessary to predict PPI. The study also showed that port service has the highest impact while port economics has the lowest impact among the six criteria on PPI for inland waterway ports.”

Jesús Muñuzuri, Luis Onieva, Pablo Cortés, José Guadix (2020)
“Using IoT data and applications to improve port-based intermodal supply chains.” Computers & Industrial Engineering Volume 139
https://www.sciencedirect.com/science/article/pii/S0360835219300488

From the abstract:

“The complexity of port terminal operations and intermodal transshipments has pushed the introduction of information and communication technologies (ICT) to assist the multiple

stakeholders involved in the multiple decision-making processes. More recently the development of systems based on the Internet of Things (IoT) represents a further step in the automation of data acquisition and processing. We present here an IoT system designed to optimize, manage and monitor container transport operations along an intermodal corridor, combining rail scheduling and inland vessel navigation." "[…] This system is currently operative at the Port of Seville, the main transshipment node in the Madrid – Seville – Canary Islands intermodal corridor in Spain."

Klauth, J. (2026, June 12). Inside the industrial boom bringing millions of people to the South. Business Insider. https://www.businessinsider.com/why-companies-move-california-new-york-europe-southern-states-2026-6

This article describes how due to California's regulatory paralysis and extensive costs associated with doing business in the state, shipping companies are now incentivized to route their traffic to ports in other states, specifically southern states like Texas and Louisiana who are both spending heavily on shipping infrastructure to capitalize on this trend. This directly cuts down on California's revenue and port activity. Another cause highlighted in the article is the significant freight theft at California ports where TEUs are broken into and shrinkage occurs and is a major reason pacific shipping is taking the longer sea route to these southern ports in order to have more secure facilities for their goods and reduced operating costs overall. This will have knock on effects for inland ports as the reduction in freight received at sea directly results in lower flows of goods inland.

Port of Long Beach (2026) "TEUS ARCHIVE: 1987 TO PRESENT BY MONTH" The Port of Long Beach. URL: https://polb.com/business/port-statistics/#teus-archive-1995-to-present

An aggregate data source that lists inflows and outflows of Twenty Foot Equivalent Units (TEU)s on a monthly basis from the time period of 1987 to the current day. It should be noted that the data closer to current year is more comprehensive and dates further out (early 90's and before) are relatively sparse.

Port of Richmond Website
https://www.ci.richmond.ca.us/102/Port-Operations

Provides information on the inland ports operations of the port of Richmond.

Port of Stockton Strategic Plan Framework
https://www.portofstockton.com/wp-content/uploads/2025/04/Strategic-Plan-Framework_Final_4.2.25-1.pdf

This is the long term strategic plan for the port of Stockton and provides ample information on their operations and customers.

City of West Sacramento (N.D.) "Port of West Sacramento" URL:
https://www.cityofwestsacramento.org/government/departments/city-manager-s-office/port-of-west-sacramento

Provides a variety of resources that might be of interest for analyzing port of west Sacramento operations. Though it should be noted the website appears relatively old and so it might be worth following up with the site administrator to see if there is more recent information than these documents.

Port of West Sacramento (2013) “Port of West Sacramento Business Plan March 2013” https://www.cityofwestsacramento.org/home/showpublisheddocument/18824/638518799114400000

Potentially useful document that covers the overall business plan of the port of west Sacramento. This is as of 2013 but information such as major customers and major commodities is likely still usable and there might be a more recent document.

Riker, D. (2022) “State Level Import Penetration”. U.S. International Trade Commission. URL: https://www.usitc.gov/publications/332/working_papers/state_level_import_penetration_03-24-22.pdf

It’s important to note that this is a working paper from 2022 that develops a model for how far imported goods penetrate into the United States. In other words, how far into the US do these imports make it from port to their destination. While not published in a scholarly publication to my knowledge this research was intended to support internal decision-making at the United States Trade Commission and so can be viewed as authoritative. The paper is broader than California as it spans the continental united states but the insights generated can be useful in a California context.

From the abstract:

“I develop a structural econometric model of import penetration in different parts of the United States and then estimate the parameters of the model using data for the furniture industry, as well as several other U.S. manufacturing industries. The model is designed to address the limited availability of sub-national data. After estimating state-level import values and penetration rates, I simulate the effects of changes in tariff rates on consumer prices and domestic employment in different states. The model suggests that estimates of the local labor effects of imports can be improved by incorporating data on the location of import entry.”

Retamero José Moyano, & Camarero, O. A. (2025). Optimizing intermodal Port–Inland hub systems in spain: A capacitated multiple-allocation model for strategic and sustainable freight planning. Journal of Marine Science and Engineering, 13(7), 1301. doi:https://doi.org/10.3390/jmse13071301https://www.proquest.com/docview/3233227653?pqorigsite=gscholar&fromopenview=true&sourcetype=Scholarly%20Journals

From the abstract:

“This paper presents an enhanced hub location model tailored to port–hinterland logistics planning, grounded in the Capacitated Multiple-Allocation Hub Location Problem (CMAHLP). The formulation incorporates nonlinear cost structures, hub-specific operating costs, adaptive capacity constraints, and a feasibility condition based on the Social Net Present Value (NPVsocial) to support the design of intermodal freight networks under asymmetric spatial and socio-environmental conditions. The empirical case focuses on Spain, leveraging its strategic position between Asia, North Africa, and Europe. The model includes four major ports—Barcelona, Valencia, Málaga, and Algeciras—as intermodal gateways connected to the 47 provinces of peninsular Spain through calibrated cost matrices based on real distances and mode-specific road and rail costs. […] Results confirm the central role of Madrid, Valencia, and Barcelona, frequently accompanied by high-performance inland hubs such as Málaga, Córdoba, Jaén, Palencia, León, and Zaragoza. Cities with active ports such as Cartagena, Seville, and Alicante appear in several of the most efficient network configurations. Their recurring presence

underscores the strategic role of inland hubs located near seaports in supporting logistical cohesion and operational resilience across the system."

Robert Lim, Zhen (Sean) Qian, H.M. Zhang, "Development of a Freight Demand Model with an Application to California", International Journal of Transportation Science and Technology, https://doi.org/10.1260/2046-0430.3.1.19. URL: https://www.sciencedirect.com/science/article/pii/S2046043016301034

From the abstract:

"This paper discusses the disaggregation of the Federal Highway Administration's Freight Analysis Framework (FAF) database (version 3.0) on freight origin-destination data and the development of linear regression equations to describe the relationships between commodity-based freight trip productions/attractions to specific economic variables. Instead of generating a production/attraction equation for each commodity, commodities are grouped in certain ways to simplify model development and application. We consider three grouping methods and two model selection criteria (with and without intercepts), which are compared in terms of goodness of fit with two data sets (FAF versions 2.0 and 3.0). Furthermore, the freight generation models are validated using county-level economic data in California and applied to predict year 2015 commodity outputs. The results of this study can help city, county, metropolitan and state level planning agencies develop their own customized freight demand generation models without performing costly large-scale surveys."

Smith, J., Bingham, P., Smith, D. (2022) "Multiperspective Analysis of Pandemic Impacts on U.S. Import Trade: What Happened, and Why?". Transportation Research Record: Journal of the Transportation Research Board. URL: https://journals.sagepub.com/doi/full/10.1177/03611981221098663

From the abstract, truncated for clarity, full abstract and documents available at the link above: "U.S. container ports have experienced unpresented congestion since mid-2020. The congestion is generally attributed to import surges triggered by heavy spending on consumer goods during the COVID-19 pandemic. […] How can the shipping industry and government organizations predict the end of the current surge and anticipate future surges? […] The research goes beyond transportation data sources to examine broader connections between import volume and indicators of economic and retail industry conditions. The strongest and most useful relationship appears to be between retail inventory indicators and containerized import growth. […] In a broader sense, an awareness of the linkages between consumer demand, retail chain responses, and containerized import volumes could better inform port, freight transportation, and government planning and policy choices."

Snape, G. (2026). *Inland Cargo Boom: Is nearshoring rewriting the risk map for marine insurers?*. Insurance Business. https://www.insurancebusinessmag.com/ca/news/auto-motor/inland-cargo-boom-is-nearshoring-rewriting-the-risk-map-for-marine-insurers-568829.aspx

Nearshoring and tariff-driven supply chain shifts are moving cargo transport away from ocean shipping and toward inland rail and cross-border trucking, reshaping marine insurance exposures. Companies have responded to trade volatility by stockpiling goods and altering shipping routes, which increases accumulation risks and introduces new exposure points for insurers. Growing domestic manufacturing in North America is driving demand for inland transit coverage, especially in sectors like automotive where parts increasingly move within the region rather than overseas. As cargo flows shift inland, insurers must adapt underwriting to address

perils like theft, accidents, congestion, and climate-related accumulation risks. Overall, nearshoring is creating a structural change in how goods move—and how marine insurers must manage risk.

Tawfik, A., & Shah, U. (2023). Analysis of freight movements in the San Joaquin Valley. https://doi.org/10.31979/mti.2023.2131

Research article covers a variety of data sources for freight movement in the San Juaquin valley that should be useful in general

Wu, Z. (2024) "Examining the influence mechanisms of gateway ports on inland ports in the context of Port regionalization - A case study of the Yangtze River Port system". Transport Policy Volume 157. https://www.sciencedirect.com/science/article/pii/S0967070X24002270

From the abstract:

"This study examines the influence of gateway seaports on inland ports within a river port system, focusing on the Yangtze River port system as a case study. The research initially employs a fixed-effects panel model to confirm the overall positive impact of Shanghai Port on Yangtze River inland ports. Subsequently, using Panel data model with individual-specific slopes, this study reveal that Shanghai Port positively affects each inland port, but the magnitude of this impact varies significantly. The research further employs a panel threshold regression model to dissect the mechanisms through which Shanghai Port influences inland ports in terms of geographical, operational, and economic distances. In terms of geographical distance, the influence of Shanghai Port on the throughput of Yangtze inland ports diminishes as the navigational distance increases. Notably, inland ports located downstream on the Yangtze River are the first and most impacted, marking the downstream area as an early influencer in the port regionalization process. As to operational distance, Shanghai Port exerts a stronger influence on inland ports with higher throughput levels, as opposed to those with lower throughput. With respect to economic distance, inland ports in cities with higher economic development are found to be less influenced by Shanghai Port compared to those in less economically developed regions. This nuanced understanding provides invaluable insights into the interconnectedness of major gateway ports and their inland counterparts."

Zhuang, P., Li, X., & Wu, J. (2023). The Spatial Value and Efficiency of Inland Ports with Different Development Models: A Case Study in China. Sustainability, 15(17), 12677. https://doi.org/10.3390/su151712677

From the abstract:

"Inland ports have become elements of the modern transport and logistics infrastructure hub and play an important role in shaping urban spatial texture. However, the spatial dimensions of their development have received little attention in the existing literature. This paper explores the spatial value concept for inland ports, i.e., the node and place values, by using a node-place model that was adopted for passenger terminals such as metro stations or train terminals. After measuring the node and place values, our research further evaluates the efficiency of node value's impact in improving place value, which indicates the effects of node value on regional development. This paper examines the impact of inland port activities on regional development, studying 12 Chinese inland ports with various models. The results show that half of the inland ports are balanced in terms of node value and place value. Only 50% of the inland ports are efficient, in terms of the contribution of node value to place value, in promoting the regional economy. Inland ports in a balanced position are usually more efficient. This study provides new

evidence of inland ports promoting regional development, as well as a basis for policy-making for future inland ports.”