DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Development of a Freight System Conceptualization and Impact Assessment (Fre-SCANDIA) Framework

Evaluating the complexities of the state's supply chain system by assessing both benefits and impacts through a set of case studies.

Planning, Policy, & Programming

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Project Title:
Development of a Freight System Conceptualization AND Impact Assessment (Fre-SCANDIA) Framework

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WHAT IS THE NEED?

California has the largest State economy in the U.S. and is a major supplier of agricultural and high-tech manufactured products for the rest of the nation. The State's freight transportation system is critical to California's economy and to the economies of other U.S. states. However, the vehicles, equipment, and facilities used by the different economic agents that conduct these freight operations generate a great deal of externalities including congestion, environmental emissions, and safety issues, among other impacts.

For example, freight accounts for about half of toxic diesel particulate matter (diesel PM), 45% of the emissions of nitrogen oxides (NOx) that form ozone and fine particulate matter in the atmosphere, and 6% of the greenhouse gas (GHG) emissions in California. These statistics however, only include emissions from vehicles and the equipment used to move freight at seaports, airports, railyards, warehouses and distribution centers. The actual impacts from freight, including the necessary infrastructure, could be much higher. Different operational patterns, seasonality, lack of freight data, and the multiplicity of economic agents, supply chain structures, and their interactions hinder the understanding of the freight system. These factors make the actual estimation of the full impacts a complex task. At the same time, public agencies are developing policies and methodologies that seek to minimize the negative impacts of the system, while trying to maximize its benefits.

In order to take these policies from well-intentioned to effective, there is an urgent need to be able to evaluate the entire (end-to-end) supply chains that move the goods and services

required for this vibrant economy. This requires the understanding and availability of a full-system conceptualization that characterizes the components and structural forms of the key types of supply chains active in the State. Moreover, there is a need for an initial assessment of the impacts of the freight flows for different industry sectors, and commodities entering and exiting the State.

WHAT WAS OUR GOAL?

The goal of this project was to develop a framework based on a Life Cycle Impact Assessment Methodology (LCIA). Additionally, this effort leveraged ongoing research conducted by the research team to develop a multidimensional cost/benefit appraisal for analyzing transport projects that considers 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.

WHAT DID WE DO?

Task 1: Comprehensive literature review.
The team conducted a comprehensive literature review in three fronts:

- Characterization of the freight system with emphasis on California. This clarified the overall scope of the processes and stakeholders involved in moving particular goods and to determine what decision-makers are relevant.
- LCA methodologies, to identify research trends that provide an adequate starting framework.
- Impact assessment methodologies that include direct and indirect impacts for users and non-users.

Task 2: Characterization of key supply chain structures and involved stakeholders.
In this task the team identified and characterized supply chain structures relevant to the freight system in California.

Task 3: Development of system conceptualization and impact assessment framework.
The framework considers the key components and structures of the various supply chains, the interactions, and a number of critical impacts produced by the freight system. The team explored different impacts, and data needs necessary to assess them. The resulting aggregate framework is able to estimate the environmental and health impacts of freight flows. The framework builds on the Environmental Protection Agency's Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI). The impacts include: ozone depletion, climate change, acidification, eutrophication, smog formation, human health impacts, and ecotoxicity.

Task 4: Selection of case studies and data collection.
The team identified a number of potential case studies (supply chains types, industry sectors, commodities, layers of the economy) and the available information and data. For those cases, the team gathered and processed information from secondary sources. Specifically, the team evaluated supply chains in the electronics, retail, and food manufacturing industries. In addition, the team estimated the impacts for freight intensive sectors, and commodities types in the State.

Task 5: Evaluation of the developed methodology.
The framework was applied to the case studies. This task identified gaps in the literature as far as which steps or processes are difficult to model or determine their impacts, and data availability.

Task 6: Final report and scientific paper writing.
This task involved reporting activities. A final report

was submitted to the panel for review. A research article was produced by the research team.

WHAT WAS THE OUTCOME?

The research developed a framework to conceptualize the freight transportation system and assess its impacts (Freight System Conceptualization and Impact Assessment Framework). Specifically, the framework is a commodity-based framework that assesses the environmental and health impacts of freight flows. The empirical analyses show the industry sectors generating the largest impact to the system. However, some of these sectors may be using specific mode shares that reduce the intensity of the impacts at a disaggregate level. This is the case for those sectors that have large rail utilization. The research reached similar conclusions when evaluating the impact at the commodity level.

The results also evidence the need for additional research to understand and assess responsibility for the impacts generated by freight movements. Two different perspectives cold result in different analyses for the LCA estimates. For example, the results per industry show the impact of the flows generated by the establishments form these industries; however, the vehicles and carrier companies in NAICS 48 (with the exception of private trucks, which are mostly operated by the companies) generate these impacts. Should the impacts by allocated to the generating company (e.g., manufacturer, retailer, hotel) or the hired carrier? Moreover, the results show that only concentrating in NAICS 48-49 may not include the ~10% impacts from the flows transported by the establishments private fleets, which are not included in the NAICS 48 flows.

WHAT IS THE BENEFIT?

The framework analyzes the main components of key supply chains and could serve as an impact evaluation tool. Such a framework would help identify the type of freight activities that have the largest impacts, and identify which economic agents' decisions or regulatory actions affect a particular impact the most. In addition, it will also help agencies develop and understand appropriate performance measures.

IMAGES