TRANSPORTATION RESEARCH
CIRCULAR
Number E-C169
October 2012

Measuring the Transportation System from a Supply Chain Perspective

July 11–12, 2012
Irvine, California

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Transportation Research Circular E-C169

Measuring the Transportation System from a Supply Chain Perspective

July 11–12, 2012

The Arnold and Mabel Beckman Center of the National Academies
Irvine, California

Organized by

Transportation Research Board
Freight Transportation Data Committee

Kathleen L. Hancock, *Editor*
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October 2012

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001
www.TRB.org

TRANSPORTATION RESEARCH CIRCULAR E-C169
ISSN 097-8515

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Javy Awan, Production Editor; Jennifer Correro, Proofreader; Jennifer J. Weeks, Formatting

Preface

Several recent TRB data activities concluded that critical supply chain data are not currently available to inform research, planning, and policy making that impact freight movements, the transportation system, and the U.S. economy. The TRB standing Freight Data Committee held a workshop to initiate a dialogue about private sources and uses of supply chain data and to identify opportunities in which these data could be used to support public-sector decision making.

Under the auspices of the Freight Data Committee, a planning team chaired by Scott Drumm from the Port of Portland carried out the detailed planning for the workshop. This document consists of individually authored summaries from the workshop. None of the views expressed should be construed as consensus findings or recommendations on the part of all workshop participants, the planning team, the sponsoring committee, or TRB.

The planning team included professionals from the public and private sectors and academia and consisted of users, analysts, and modelers of freight transportation data. The 45 invited persons attending the workshop reflected organizational diversity as follows:

Federal	13%
State government	9%
Local, regional, port	13%
Consultants	17%
Private sector (supply chain)	13%
University	20%
Other	15%

SHRP 2 provided funding to support travel and on-site expenses.

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Introduction

SCOTT DRUMM
Port of Portland

Several recent TRB data activities have concluded that critical supply chain data are not currently available to public-sector decision makers and thus are not available to inform the research, planning, and policy making that impact freight movement, the transportation system, and the U.S. economy.

TRB Special Report 304: How We Travel: A Sustainable National Program for Travel Data identifies supply chain data as a major gap in freight transportation data (*1*). The SHRP 2 C20 Freight Modeling and Data Improvement Strategic Plan (completed in 2011 and scheduled to be published in 2012) also highlights the importance of public-sector freight modeling and innovative approaches to data collection in enabling freight models to more accurately reflect the decision-making processes of private-sector freight shippers, receivers, and carriers. This suggests a need for public-sector decision makers to better understand the supply chain. In 2010 the TRB Freight Transportation Data Committee (ABJ90) organized a conference, Freight Data Research: A Roadmap, in which it identified supply chain data among the main shortcomings of comprehensive data collection. The conference summed up a strategic outline of research needs, Freight Data Research Roadmap: The Big Ideas, which included investigating how to collect and use supply chain data.

In response to these findings and as part of its ongoing Research Roadmap, the TRB Freight Transportation Data Committee hosted the July workshop to advance the understanding of if and how public-sector decision making could be improved by having better supply chain information. The specific objectives of this workshop were to

- Review current supply chain applications and data uses for the public sector;
- Explore the decision-making processes involved in public-sector investments and the value of enhanced supply chain information;
- Identify potential examples of specific public uses of supply chain data as well as the types of users who could benefit from its availability; and
- Explore future actions and research that could further this approach.

The structure of the workshop consisted of 1 day of information gathering and exchange through three sessions with invited speakers and an interactive session to capture the essence of the day. This was followed by a working session of the planning committee to identify how this information met the workshop objectives and to identify themes that might lead to specific research to support these objectives.

The opening session featured four keynote speakers who set the stage for the workshop's discussions. Joseph Schofer, Northwestern University, who chaired the oversight committee for TRB Special Report 304, summarized the premise of the special report and its recommendations related to supply chain. William Bostic presented the U.S. Census Bureau's investigation and use of supply chain data and the lessons they have learned. Chris Caplice, Massachusetts Institute of Technology, who is the principal investigator for National Cooperative Highway Research Program (NCHRP) Project 20-83(1): Economic Changes Driving Future Freight Transportation,

showed the interrelationship between the economy and supply chains and why making informed public infrastructure investment decisions is critical. Highlighting the work he did as the principal investigator for National Cooperative Freight Research Program Project (NCFRP) 35: Multimodal Freight Transportation Within the Great Lakes–Saint Lawrence Basin, Marc-André Roy, CPCS Transcom Limited, described how supply chain data can be used by the public sector using specific supply chains and commodity flows in the Great Lakes region.

The purpose of the second session was to review supply chain applications, how these are employed by practitioners in various industries, availability of these applications for public use, and associated opportunities and barriers. Panelists included John Gray, Association of American Railroads; John Isbell, Starboard Alliance (formerly NIKE Logistics); Steven Fox, Norbridge, Inc.; and Christopher Mazza, International Asset Systems.

The third session considered the factors underpinning investment decision making in the public sector and considered the potential value of incorporating supply chain data into that process. Panel members included Ken Allen, H-E-B (retired); Christina S. Casgar, San Diego Association of Governments; and Gill Hicks, Cambridge Systematics, Inc.

This circular provides a synopsis of the information from the first day, followed by the initial themes that were identified for further development.

REFERENCE

1. *Special Report 304: How We Travel: A Sustainable National Program for Travel Data.* Transportation Research Board of the National Academies, Washington, D.C., 2011.

Understanding the Supply Chain Perspective
A Synopsis

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JOSEPH L. SCHOFER
Northwestern University

This workshop addressed key questions about the collection and public use of data describing the supply chain to measure and assess the performance of the transportation system. These include defining "supply chain" for this purpose, assessing the key public needs for such data, determining what aspects of system performance are most important and appropriate to measure using supply chain data, exploring ways to accomplish that measurement, identifying how the data might be collected, discussing public- and private-sector roles in this process, and outlining a program for collecting and disseminating the data.

A group of public- and private-sector stakeholders was gathered to exchange information on the needs and use of supply chain data. The group included private-sector practitioners from various industries that use the multimodal transportation system. Public-sector participants discussed the availability of supply chain applications for public use, as well as potential opportunities and barriers to the acquisition and use of these data at various levels of government.

SUPPLY CHAINS AND SUPPLY CHAIN DATA

A definition of supply chain by Thomas Freidman was presented as "supply-chaining is a method of collaborating horizontally—among suppliers, retailers, and customers—to create value". Discussions of this definition resulted in the conclusion that supply chains are viewed differently by the different stakeholders that participate in the process, including shippers, carriers, third-party logistics service providers (3PLs), and others.

Freight transportation and supply chains are important at the national level because freight has no boundaries and the scale of the impacts of freight movement extends from local to global, with impacts reaching several aspects of the economy, including congestion, safety, the environment, jobs, and most important, economic competitiveness.

Good data are important for understanding supply chains and freight transportation; however, several challenges impact the collection of freight and supply chain data:

- Who is gathering the data and how;
- Private-sector roles, risks, and benefits of data sharing;
- Who knows how and where shipments go;
- Who can and will share data;
- Who are stewards with access to supply chain data; and
- Privacy and data security.

These challenges were part of the discussion that took place during the workshop.

Macro-economics, technological change, and market trends at all spatial levels are difficult to predict, and all can have major impacts on supply chains. These are forces outside the control of public-sector stakeholders. In response to such factors, supply chains typically adapt through changes in

- Locations of activities (manufacturing, sources, or distribution centers);
- Selection of transportation modes and routes; and
- Value, frequency, and scale of shipments.

This adaptability is important to the effectiveness of supply chains, but it can make supply chain data more difficult to track and interpret, and it presents challenges to planning both supply chains and the infrastructure that supports them.

In response to external uncertainties and the fluidity of supply chains, the concept of scenario-based planning was presented as a promising method, particularly for logistics planning. The underlying principle is that *preparing* for potential outcomes is more effective than *predicting* future events.

SUPPLY CHAIN DATA AND PERFORMANCE MEASUREMENT

The focus of this workshop was on the potential for using supply chain data to improve understanding of the functioning of the freight transportation system, and to measure and analyze the performance of that system.

Shippers, carriers, wholesale vendors, and others in the supply chain are concerned about the performance of the freight logistics system because highway, rail, and port operations affect their costs and profits. At the heart of the public-sector interest in freight system performance is the hidden cost to economic growth and competitiveness that could be incurred if the transportation infrastructure fails to serve the freight sector effectively and efficiently. To assure the nation's competitiveness, supply chain costs need to be minimized for both public and private sectors. To do that, public agencies need a better understanding of supply chain planning as performed by private firms, and private firms need a better understanding of the public sector's evolving supply chain perspective and its approach to managing the supporting infrastructure.

The shared need to understand and manage freight system performance raises the question of performance for whom. Performance measures will be different for the private and public sectors. Carriers, policy makers, regional planners, etc., have different objectives, leading them to measure different aspects of the supply chain. By and large, shippers assess freight transportation performance on the basis of total logistics cost, transit time, and reliability and the related risks. Public-sector stakeholders do not necessarily think in these terms. They may focus on capacity and congestion at the link, node, or sometimes corridor level. Private-sector managers usually have a shorter time frame for performance assessment, reflecting the flexibility of supply chains. Public-sector decision makers, on the other hand, are typically concerned with long-lived infrastructure, the use of which may change substantially over time. Public-sector decisions may not be flexible enough to accommodate changes in supply chains; by the time a large infrastructure project is built, the need may no longer exist or have changed.

To understand supply chains, identifying and understanding the roles of the different players in the process is critical, not only carriers and shippers, but also the 3PLs, equipment lessors, terminal operators, insurers, etc. A key decision maker that drives the supply chain is the beneficial cargo owner or importer of record who takes possession of cargo at the destination and who may ultimately make decisions on choice of mode and route.

Supply chains are inherently multimodal and intermodal, and this makes addressing commodity or supply chain-specific multimodal and multijurisdictional constraints and barriers important in measuring performance for freight system planning and management. These barriers to system performance include

- Modal integration challenges;
- Lack of jurisdictional coordination;
- Lack of multimodal funding mechanisms;
- Modal inequality—when a mode may have a favored position in the market because it does not pay its share of infrastructure costs;
- Inadequate or absent intermodal data and performance metrics;
- Lack of awareness of the importance and role of the freight transportation system; and
- Labor constraints.

Adopting a supply chain approach to freight infrastructure performance measurement should be helpful for assessing and addressing such constraints. Both public and private perspectives might be better served, and better integrated, by collaborative development of supply chain-based regional-scale strategic frameworks to identify multimodal freight transportation problems and priorities, and to guide gateway and corridor or supply chain–specific performance analyses.

FREIGHT MODELING AND SUPPLY CHAIN DATA

Freight flow modeling is particularly important for the public sector that is currently responsible for planning, building, and managing much of the freight transportation infrastructure. Scenario planning may take some pressure off the need for forecasting, but anticipating the future is still important, particularly to test and evaluate proposed options and policies. Building freight models using a supply chain framework is probably necessary to develop a reliable and policy-sensitive forecasting capability. Traditional freight models are not responsive to changes in external and internal factors that drive the adaptability of supply chains. Models need to reflect how shippers, carriers, and other entities in the logistics process make decisions. This motivates the introduction of supply chain concepts into new models, but the complexity and variability of supply chains makes this modeling process especially challenging. For example, every supply chain is different. Not all of them require a fast shipment but instead, the predictability or reliability of the system is more important.

Development of these models requires access to supply chain data. Supply chain data for individual movements clearly originate and reside with private-sector entities, typically many such entities in a single supply chain. The challenge is to secure private-sector supply chain data for public purposes, and at the same time to protect private interests. There are several impediments to obtaining supply chain data for public use. The most important is that shippers

and carriers consider their supply chains to be a strategic advantage. Logistics service providers do not want their competitors to know how they are managing their business or the volumes of business they are handling. It is difficult to assure confidentiality of proprietary private-sector data, including vendor locations, volumes, and rates, when it is given to another party. If the private-sector entities are to accept this competitive risk, they need some assurance that reasonable efforts will be made to secure the data, and, importantly, that the use of those data will bring benefits back to the providers—the private-sector organizations that make it available—through improvements in infrastructure and policies.

COLLECTING SUPPLY CHAIN DATA

Two obvious, existing sources of supply chain data were identified: bills of lading maintained by shippers and carriers' records. Such data are well maintained if "management" requires it or a regulatory requirement exists. However, the complexity and variability of supply chains will require more sophisticated approaches to data collection, integration, and fusion that capture end-to-end flows, modes, interchange points, and routes. Establishing these approaches would require a substantial research and development effort.

One of the challenges that often occur in public-sector data collection efforts is the tendency to ask for "all the information you can provide." There is natural resistance to such blanket requests because of the issues discussed above: proprietary concerns and doubts about how the data will be used. It is important to distinguish between information needed and information wanted. To identify what information is really needed, identifying the decisions that are being made with that information is critical. This is the important difference between measuring simply to measure and having measures that will guide decisions.

PUBLIC- AND PRIVATE-SECTOR SUPPLY CHAIN DATA NEEDS

It is important to identify what public-sector decisions need to be made with supply chain data before requesting additional data from the private sector.

The public sector has limited insight into proprietary supply chain data. Freight is only one component of the public-sector agenda for managing transportation infrastructure. Information that is usually available for the public sector includes

- Growth forecasts: population, housing, and jobs, which are correlated with freight demand;
- Zoning and land use data including warehouse locations;
- Travel demand model forecasts for passenger and freight trips;
- Truck trip counts at sample locations; and
- Transportation infrastructure information and locations.

Data needed and used by the private sector include

- Population growth in the trade area,
- Demographic profile of population,

- Current and future highway congestion levels,
- Government trends in managing congestion, and
- Future workforce profile and availability.

Supply chain data of importance to public agencies may include

- Flows (volumes, types) on and through links, terminals, and modal interchanges and
- Locations of resource, manufacturing, distribution, retail, and recycling centers.

Public agencies may also require additional supply chain metrics to support their public benefit mission, including measuring externalities, equity funding considerations, and balancing public versus private costs and benefits.

CONCLUDING OBSERVATIONS

Inclusion of supply chain data has the potential to provide a more comprehensive and realistic picture of freight movements and logistics, in contrast to currently available link volumes and simple origin–destination freight flows. Thus this integration offers promise for measuring the performance of the transportation system and its components, particularly infrastructure elements (critical links, corridors, terminals, etc.), in ways that better reflect the role of public infrastructure in regional and national economic competitiveness. Therein lays the public-sector interest in these data. However, there is limited experience with the collection and application of supply chain data for this purpose.

Some participants at the workshop suggested the value in documenting contemporary and emerging applications of supply chain data for performance measurement and freight modeling, and in the process, identifying both the benefits of and barriers to such uses. Pilot applications of the collection and use of supply chain data, perhaps in smaller cities, regions, or simple corridors could provide a better basis for making the case for broader more comprehensive efforts. Public–private collaborations in such pilot tests could be valuable for identifying benefits of data sharing as well as ways to manage the disclosure risks for private partners. However, before engaging the private sector, it will be important for the public sector to identify very clearly the data elements that are required and the uses for that data. The Federal Highway Administration or NCHRP could be logical sources of support for such work.

More extensive use of supply chain data, for example in the development of advanced freight models or exploratory performance measurement, may require more sensitive (proprietary) data. To ensure data protection it may be possible to set up a secure data center, similar to the U.S. Census Data Centers, within which researchers could work with proprietary data for analysis and modeling building, with the assurance that no firm-specific data would be released.

Research Themes for Use of Supply Chain Data and Concepts in Public-Sector Decision Making

SCOTT DRUMM
Port of Portland

KATHLEEN L. HANCOCK
Virginia Tech

One of the key points raised at the workshop was that the freight data community needed to develop an understanding of supply chain so that it was clear what was being referenced. Although certainly not contradictory, there are clear differences in what is meant by that term in the private and public sectors. To ensure that the ideas from the workshop were directed to the needs of public-sector decision making, a working definition was developed and is provided in the next section.

In addition, several other recurrent observations informed the development of the research themes:

- Supply chains are dynamic. Decisions are made in real time and are typically short term in nature. The public sector wrestles with large-scale, high-cost investments in infrastructure that is static by comparison.
- Individual experiences in getting data about supply chains are varied. In some locales, firms gladly provide public-sector planners and analysts with data, while in others they are unable or unwilling. The kinds of data that the public sector requests are also quite diverse and the requests are often unstructured, possibly leading to the varied levels of responses.
- To some in the public sector, freight data and supply chain data are synonymous, when in reality they are very different. However, some freight data may also fulfill the need for what is thought to be a supply chain data need.
- While mode of transportation is critical for public-sector understanding of supply chains since it is directly associated with infrastructure, mode is not a direct concern for the private-sector operating supply chains.

With these and the working definition as a basis and from the presentations and discussions during the workshop, several broad themes were distilled that could provide the basis for future research and integration with other freight and data research, programs, and activities. The themes that evolved include the following:

- Identifying applications of supply chain information for public-sector freight transportation planning and performance measurement;
- Identifying case studies of how interviews with individual supply chain professionals and firms can provide a basis for understanding the nexus between supply chain and state or local transportation systems;
- Making use of existing, although nontraditional, freight and logistics data for understanding supply chains; and

- Understanding and incorporating warehousing, a critical component of transportation within the supply chain context which is currently not considered in public-sector activities.

Initially when planning the workshop, there was a sense that a comprehensive supply chain data collection program would be among the priority items for research. However, as the workshop discussions progressed, it became clear that the freight data community is not yet at the stage to articulate such a research effort. Instead, the focus became more on developing the necessary understanding while leveraging existing resources and activities that could support that development.

Working Definition of Supply Chains as Applied by Public Agencies

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San Diego Association of Governments

One of the main objectives of this workshop was to better enable informed discussions of national, state, regional, and multistate freight policy and system investment priorities. To frame the information from the workshop and discussions moving forward, a working definition of the supply chain as it relates to public agencies, an affirmation of the value of supply chain information to this process, and recognition of a broadened analytical view of supply chain freight data is necessary.

WORKING DEFINITION

A supply chain view of the transportation system must collectively consider all aspects of the commodity being shipped. A supply chain view takes a systems perspective that considers the commodity, the value, the volume, the possibility of market shifts, the original source, the ultimate destination, and intermediate routing of products from production to consumption to recycling. It recognizes that freight crosses jurisdictions, modes, industries, and is constantly changing to meet higher service standards and lower cost expectations. This supply chain view which encompasses all freight activity from origin to destination is different from a traditional public perspective, which is often mode specific and usually bounded by regional geography. It is also different from the classic business perspective which includes integrating logistics activities within and across companies to transform raw materials into finished products.

ADDING PUBLIC VALUE

Applying a supply chain perspective to the public-sector view of transportation systems has the potential to produce synergistic value in many ways—for example,

- Informing transportation system management;
- Strengthening multistate (and global) understanding of freight flows;
- Planning responses to transportation emergencies and managing resiliency in the event of a major supply chain disruption;
- Improving the local, regional, and national understanding of economic competitiveness;
- Informing freight transportation supply chain policies in transportation agencies [departments of transportation (DOTs)] and planning organizations;
- Assisting local planners in identifying freight bottlenecks;
- Assisting planners in understanding emissions or emission reduction strategies from a supply chain perspective;
- Applying a common supply chain terminology that can build understanding between public planners and the private carriers and shippers; and

- Complementing a supply chain approach to the DOTs, and U.S. Department of Defense, U.S. Department of Commerce, and other federal agency logistics.

ADJUSTING FREIGHT DATA COLLECTION AND ANALYSIS TECHNIQUES

Pertinent to public-sector collection and use of freight data, applying a supply chain perspective suggests the need for a broader interrelated, intermodal supply chain view. The supply chain view encompasses new inputs such cost, commodity, routing, staging, etc. An optimized supply chain view of data requires examining nodes of activity to make sure they work in concert and that they are integrated and viewed as linked activities. This broadened view will also require a comparable adjustment to analysis techniques, ultimately resulting in a better understanding of transportation system investments.

Supply Chain Information for Public-Sector Freight Transportation Planning and Performance Management

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Federal Highway Administration

ALISON J. CONWAY
City College of New York

Freight transportation planning requires good data to make good decisions. Freight-related data is collected and analyzed to identify and understand goods movement, economic and transportation patterns along with needs, opportunities, deficiencies, and alternative courses of actions. Although there are many sources of freight information, virtually all current sources are mode specific and have limitations for freight transportation planning. The supply chain perspective provides the potential to bridge limitations in existing data and broaden the understanding of how goods move in a variety of planning applications.

STATE AND REGIONAL FREIGHT PLANS: SYSTEMS AND POLICY PLANNING

A core element of system and policy focused freight planning is an understanding of freight flows, key industry characteristics, and connections back to economic activity. This often involves describing and analyzing the characteristics of freight, including what kinds of goods are moving, how much is moving, by what modes, and where the goods originate and are consumed. It also involves mapping of supply chains of key industrial sectors. Typical data sources include the following:

- Commodity Flow Survey (CFS) for national- and state-level data on domestic freight shipments in a variety of industries. Data are provided on the types, origins and destinations, values, weights, modes of transport, distance shipped, and ton miles of commodities shipped;
- FHWA's Freight Analysis Framework (FAF) for information on interstate freight movement;
- County business patterns for information on number of establishments, employment, and payroll data by industry; and
- Interviews with key freight stakeholders to gain insights and information on the present freight characteristics of major industries and the relative importance of efficient freight service to their businesses.

While these data sources can provide information on the various modes used to transport freight and major commodities, they lack the ability to present a comprehensive picture of the transportation inputs and outputs that function together to support a supply chain of a particular industry or commodity. The introduction of a supply chain perspective provides the public-sector planner with a new lens through which to view the transportation and economic connections of a region, state, industry, or commodity. By understanding the supply chain, the public planner can better map key industries to known commodity flows, transportation routes, and modes. The

linkage between "employers" and freight transportation can be better understood, particularly the connection between freight trips that may otherwise be seen as unconnected. Insight through the supply chain perspective can allow better decision making on infrastructure priorities, routes, modes and mode shift, pricing, demand elasticity, redundancy and resiliency planning, and time-of-day use and shifts.

Entering the world of supply chains and supply chain data can be a daunting proposition for the public planner and can result in frustration and dead ends if approached incorrectly. In the technology-driven supply chains of today, even the simplest supply chain can involve layers of drilling down into the inner workings of inventory, cost, order, utilization, and cycle time to acquire the desired data. Private-sector presenters from the workshop highlighted an important distinction between the detailed and closely guarded supply chain execution data that drives the internal workings of a specific supply chain and the higher level supply chain planning that drives the external transportation requirements. Focusing on this external higher order supply chain information will provide the type and level of data useful to the public planner. Another related approach is to focus on the critical 10 to 12 industries in a study area. Often these industries account for the majority of supply chains that impact the regional economy and transportation system. A focused approach allows the public planner to successfully begin incorporating the supply chain perspective with a manageable dataset.

A planning topic of particular interest to the public planner is the ability to frame scenarios for different futures. Chris Caplice of Massachusetts Institute of Technology reminded workshop attendees that planners generally have a poor ability to accurately predict the future but strong ability to prepare for the future. In preparing for the future, the focus is preparing for a particular effect as opposed to a particular event. Application of the supply chain perspective provides the ability to understand and analyze the effects of future events on the transportation system and industry by providing insight into the linkage and connections between elements of the supply chain. Ultimately this will allow the public planner to better prepare for the future by understanding the stressors to look for to indicate an issue and recognizing the levers that can be pulled to successfully compensate for changes or impacts to the transportation system.

CORRIDOR AND PROJECT PLANS: EVALUATING ALTERNATIVES

Development of a corridor- or project-specific plan typically requires going into detail to evaluate a series of alternative courses of action. The supply chain perspective can provide the planner with a more holistic picture of freight moving through the corridor or project area. This information can better inform the study with regard to cost and efficiency impacts from different improvements, such as an operational improvement versus an infrastructure improvement, enabling planners to understand the elasticity or flexibility of the freight industry to react to different alternatives. For instance understanding the key supply chains using a corridor can provide a better understanding of size and weight implications. An example would be the determination of whether a supply chain needs heavy materials that require special permits or are the materials light and not impacted by a change in weight regulations. Similarly, an understanding of the entire supply chain provides a better understanding for modal shifts.

ECONOMIC DEVELOPMENT

Freight facilities are recognized by many public agencies as opportunities for employment and economic development. As NCFRP Project 23 points out, the ways that transportation and freight facility requirements interact with other economic factors to influence location decisions made by the private sector typically are not well understood by the public sector. Applying the supply chain perspective could assist the public planner in understanding how to formulate effective economic development strategies and react appropriately to proposals for the development of public or private freight facilities. Supply chains require multiple types of facilities at different locations. Each type of freight facility has a distinct purpose with unique location needs. Understanding the combination of location factors allows for a more successful approach to economic development

PERFORMANCE MEASURES AND MANAGEMENT

Measurement and management of freight performance is of interest to both the private and public sectors. Speed, cost, and predictability (often measured as variability by the private sector and reliability by the public sector) are key indicators or measures. Disruptions to speed and reliability of freight transportation add directly or indirectly to the costs of businesses, the costs of exports, and the cost of consumer goods. Businesses compensate for added travel time from congestion, circuitous routing, or delays at inspection stations and intermodal transfer facilities by using more distribution centers, more transportation equipment, more labor, and more expensive forms of expedited transportation. Businesses compensate for reduced reliability by increasing the scheduled travel time, incurring the costs of additional distribution centers, more transportation equipment, more labor, and more expensive forms of expedited transportation.

By measuring the performance of the freight transportation system, public officials can identify bottlenecks and other problems that add costs to businesses and consumers, and target investments and other actions to counter those transportation problems.

Today, the state of the practice in tracking travel speeds, travel times, and reliability of trucks operating on the nation's major intercity highways is data on location and time collected from global positioning satellite devices on approximately 400,000 trucks. Although this provides a rich empirical data set, the focus remains largely from the highway infrastructure or corridor perspective rather than the user or industry perspective that can be provided with supply chain data.

The introduction of a supply chain perspective into performance measures and management could allow

- Tracking of a specific commodity across multiple modes or regions that it traverses as part of its journey in a supply chain. An example of this is Transport Canada's Freight Fluidity measures that measure end-to-end travel times of key commodities.
- Understanding of multiple trips within a region that make up the transportation portion of a supply chain for an industry, that, viewed separately, are random trips averaged into the indicator, but viewed together in a comprehensive manner, reveal the performance of the transportation system and economic impact for a key industry.

Returning to the earlier concept of supply chain planning, one can focus efforts into a manageable approach by identifying key industries or commodities for a region to gain an understanding of the performance of the transportation element within the supply chains.

Based on discussions from the workshop, the potential for supply chain information to inform and enhance planning, performance measure, and management is high. Further evaluation of the areas outlined in the previous sections could provide specific data needs and corresponding areas for research, along with opportunities for more structured integration of supply chain information into existing activities.

Case Studies of Supply Chain Data Informing Public-Sector Decisions

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SCOTT DRUMM
Port of Portland

Throughout the workshop, many participants cited the need to improve the integration of supply chain considerations into the freight planning, policy making, and investment decision processes. It was noted that state departments of transportation and metropolitan planning organizations have elevated freight planning but agencies were not yet cognizant of supply chain issues.

Developing a series of illustrative case studies could assist agencies in more fully understanding the importance of supply chains to transportation operations and economic development. The case studies would demonstrate the types of data that would be needed and the questions necessary to plan for acquiring these data, providing a good starting point for understanding supply chains in the absence of more publicly available and accessible supply chain data.

Several important points were raised during the workshop that public-sector researchers could consider when developing case studies:

- First, ask the right questions.
  - Identify the questions most pertinent to understanding supply chains. Is the focus economic development, lower emissions, congestion reduction, or something else? The case study needs to be focused on the specific requirement. If it is too broad it will create problems for data acquisition and analysis.
  - Firms' logistics operations generate volumes of data. Be specific about what is sought and do not make general requests hoping to glean something from a mass of data.
  - Understand what is measured by firms. It is not often that what matters to them is purely volume or time information. Much of what is measured is specific to a period of time, revenue, cost, or some other important corporate performance indicator.
  - Explain why the information is being requested and what will be done with it. Ensure that a clear benefit can be articulated for the firm sharing the data.
  - While mode is important to public-sector researchers and planners, it is not a primary focus of firms' logistics data systems.
  - Understand the differences between "freight" and "supply chain" data. Workshop participants used the terms interchangeably and this can be a source of confusion.
- Second, tie freight transportation to the economy.
  - Develop a better way of understanding linked trips.
  - Identify the impact of supply chain activity to the economy.
  - Describe how jobs factor into this supply chain discussion.

- Third, demonstrate how planning agencies can use available tools, resources, and methods to integrate supply chain information into transportation planning. Given existing data resources and methods, workshop participants outlined the following potential categories for developing supply chain case studies:
  - Data [e.g., Freight Analysis Framework (FAF), economic census], models, specific link analysis, truck flows.
  - Industries (tying together FAF commodities to industry supply chains).

Which industries are of most importance to public sector? One way to frame this is to establish a hierarchy such as the following:

- Ones that sustain civil society (food, energy);
- Ones that sustain jobs;
- Ones that grow jobs;
- International trade; and
- Geography of supply chain impacts.

Describing the geography of supply chain impacts:

Example Industry	*Local*	*Regional*	*Global*
Dairy	X	X	
Computers			X
Clothing			X
Gravel	X		

One theme that arose is the value of interviewing individual firms to improve understanding of how their supply chains operate and what is important to them. Interviews with local industries can be as important as obtaining their data, depending on the purpose. The kinds of information workshop participants have been successful in obtaining through interviews include the following:

- How firms use the local transportation system;
- Whether there are any service limitations (truck service, rail service, air routes, ocean carriers, etc.) that impact their ability to succeed in the given locale;
- Where bottlenecks occur and at what times of day;
- Volume of shipments, type of shipments;
- Overviews of both inbound and outbound shipping patterns; and
- Information on origins–destinations of shipments.

Examples of how this information could be used covered a wide range of options, such as these:

- Educate elected officials, agency leaders, and others as to how freight moves within their communities and states.
- Support requests for legislative funding of freight transportation programs.
- Identify bottlenecks or deficiencies in the transportation system.

- Evaluating how specific investments can assist local firms' logistics operations function more smoothly.

Developing a collection of specific case studies that demonstrate best practices in partnering with the private sector, preparing data requests, preparing and performing interviews with the different private-sector stakeholders, and coalescing how the resulting information was used along with lessons learned could provide a foundation for public-sector agencies to understand and make the best use of supply chain data in decision making.

Supply Chain–Related Data Sources

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Infrastructure improvements need to be based on an understanding of the full impacts and the reach of usage of the system. While there are tools and methods to collect and model data for passenger use of transportation facilities, it is widely agreed that such methods do not work well for freight usage. In contrast to the ability to survey travelers with direct knowledge of how they use the transportation system (where they started their trip and where they went, when they travel, how often, and by which modes), it is nearly impossible to find that one-stop source of information about the end-to-end transportation characteristics of freight.

One of the lessons learned from these discussions is that any attempt to assemble a new data source for supply chain data, for example something similar to the Commodity Flow Survey data, would be ineffective considering the complexity and diversity of supply chains, their very dynamic nature, the fact that there is no single source for all the elements of the supply chain, and technological limitations in capturing, storing and mining the voluminous data from all required sources.

However, there are several existing data sources that capture elements of supply chain related data that could be leveraged more by public agencies for infrastructure planning and economic development initiatives as well as for quantifying the risks involved in making long-term investment decisions.

Most large manufacturing companies, who together contribute to a substantial share of freight flows, have implemented Enterprise Resource Planning and Transport Management Systems that support their supply chain management. Companies that provide these systems maintain data on where their raw materials and components are sourced, productivity of their various manufacturing plants, volumes in their inventory, handling, trans-loading and packaging, and some level of transportation-related information depending on whether they have their own fleet or use for-hire carriers or third-party logistics service providers.

The UBM Global Trade PIERS import export trade data, the U.S. Customs and Border Protection, and U.S. International Trade Commission data on U.S. imports and exports, tariffs, future tariffs are examples of data sources that could provide information about the global supply chains that use international gateways, but rarely provide a more complete picture. Nevertheless, these are valuable data sources that are used by many private-sector companies and ports for planning.

Arguably, the most important determining factors of transportation use are supply and demand locations. The following are examples of geographic information data sources for specific industries:

- The Nielsen TDLinx data on retail consumption;
- U.S. Department of Agriculture production, supply, and distribution data;
- World Agriculture Supply and Demand Estimates;

- U.S. Geological Survey minerals industry and facilities international data; and
- Real estate brokers are a potential source for land use data, especially for warehouse and distribution center locations and transload facilities.

Studying these existing data sources across different industry supply chains is valuable for understanding change across the variety of production and distribution facilities in a given region. For example, traffic flows are less likely to be affected by a change in sourcing of iron ore or soda ash than with ongoing shifts in retail distribution center locations. Public transload facilities are more likely to change when the lease is up compared to private facilities or those requiring specialized machinery. Local and regional planning agencies would benefit from understanding which of the existing traffic flows in their region are more likely to stay or grow due to limited diversion potential, and which have the risk of shifting elsewhere.

Transportation costs and rates also play an important role in mode and carrier choice. These costs are extremely dynamic due to healthy competition between competing carriers, and businesses taking advantage of this competition. Existing data sources from the private sector for tariff or base rates include the following:

- SMC3 RateWare XL for LTL trucking rates,
- Individual railroad websites for rail rates,
- tlrates.com for truckload rates, and
- Cass Information Systems freight payments.

Assembling information from these data sets, analyzing trends in the modal rates in relation to fuel price, and correlating their impact on industry-specific supply chains can help inform planners about what factors could affect use of facilities in their regions.

There are a number of Global Positioning System and radio frequency identification–based tracking and tracing applications used by freight transportation companies that, if combined with their billing and enterprise systems, could provide specific trip flow data that planners could use to supplement the aggregate-level information from the U.S. Department of Transportation's Freight Analysis Framework or IHS Global Insight TRANSEARCH databases.

Finally, the knowledge base within supply chain consulting firms such as A.T. Kearney, McKinsey & Co., Chainalystics, Tompkins and Kinaxis, and members of Council of Supply Chain Management Professionals could be a valuable resource. The consultants' expertise in industry-specific supply chains and their experience in advising the private sector in making investments and supply chain decisions could also benefit the public sector. These professionals could help identify examples of actual end-to-end or production-to-consumption flows by industry, and by analyzing this data over a period of time, modelers could get better understanding of the nature of supply chains and what factors are important to their decisions and the tools used to support those decisions. These factors include such things as short life cycle versus long life cycle, predictable versus unpredictable demand, susceptibility to local consumer strength, wages, energy prices, and competition.

Further study is necessary to clearly identify existing datasets and understand how they are collected, what they contain, their limitations and ability to be fused together to extract information that could not otherwise be captured when using the datasets separately. The potential from such research is to enable improved multimodal decision making that improves the return to public investment in the transportation system.

Warehousing

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The supply chain systems perspective defined in this workshop incorporates intermediate routing between the original sources and the ultimate destinations of products. Intermediate points are where goods are staged en route to market. They can be gateways and modal transfer points, but most often and most ubiquitously they are warehouses and distribution centers. Their functions include consolidation and deconsolidation, market-responsive changes of direction, expediting, product sequencing, and storage. They range in size from million-square-foot complexes to simple cross-docks, and their service territories range from national to local.

Warehouse staging facilities exert a fundamental and formative influence on transportation network demand. Where products arrive and depart, the direction and distance of travel, and the volume and character of the freight vehicles that bear them all are affected by whether, when, and how staging is employed. Planning and management of the freight transportation network therefore would benefit from systematic recognition of warehousing as a demand driver and geographic determinant, and are handicapped without it.

Depiction of warehousing in freight data ideally would capture its intermediate position between production and consumption points and reveal their linkage. Nevertheless, any capture is helpful, yet existing sources of comprehensive freight flow information depict it inadequately. The federal Commodity Flow Survey (CFS) collects data on commodity shipments outbound from warehouses, but does not distinguish warehouses from other origins in its reporting. The commercial Transearch database displays warehouse and distribution shipments, but does not provide commodity or industry identification for them. Neither source links the shipments inbound to warehouses with their shipments outbound. Even so, combining commodity with warehouse identifiers in the existing data from either source could be a strong first step toward uncovering intermediate routing in supply chains.

The raw data in the CFS offer a place to start. A follow-on NCFRP Project 25(01): Estimating Freight Generation Using CFS Microdata is beginning a process by which business establishment characteristics will be joined to outbound shipping patterns as a tool for estimating freight volumes in travel demand models. This project has secured the requisite federal agency approvals to utilize the raw or "micro" shipping data from the CFS, in combination with Census Bureau data sets that supply information about the reporting establishments. The project outputs will be freight generation factors by type of business—warehouses among them—which will then be joined to land use classifications. (The project also will estimate freight consumption, but unlike the generation factors, consumption will be produced by means of modeling and not derived from primary data.)

Although the outputs of NCFRP Project 25 will be useful toward portrayal of warehouse activity, generation factors are not freight flows. However, a similar approval process could be used to develop warehouse-based commodity flows from the same micro data. The output in this case would look very much like standard CFS reporting, with a warehouse identifier added to the

commodity flow. To protect the confidential identity of CFS respondents, it may be necessary to aggregate geography for warehouse flows more than the CFS does otherwise or to suppress some records and the same care would need to be applied to nonwarehouse shipments, i.e., the difference between warehouse volumes and CFS totals. Still, the ability to compare the commodities entering an area to its outbound warehouse shipments, and the travel ranges and directions of each, would offer the first brush strokes in a portrait of industrial supply chain patterns.

The timeliness with which such an effort is launched also is important, for two reasons. First, a key contemporary trend in supply chain management is the rethinking of global networks, and the revision of staging methods in favor of more distribution centers closer to end markets. The multinational recession, the narrowing of Asian wage rate advantages, and the persistent climb in transportation fuel costs are among the influences on this trend that have arisen or become accentuated in the period since the last CFS in 2007. Analysis of 2007 warehouse freight activity, repeated for the new CFS underway in 2012, could prove exceptionally revealing of the magnitude and direction of this trend, and the regions of the country it most affects.

Second, MAP-21 charges the U.S. Department of Transportation with definition of a national primary freight network not exceeding 27,000 mi of highway. Commodity flow maps corresponding to the 27,000-mi network suggest that it is a line-haul system to which freight delivery must be connected. A reasonable hypothesis is that the line-haul system de-emphasizes the more dispersed patterns of warehouse shipments, suggesting that warehouse delivery will become an important concern for states and metropolitan planning organizations to address in competitive end-to-end freight performance. If supply chain trends in fact are adding warehouses closer to destinations, then the relative significance of delivery networks will shift in comparison to the national system. Recognizing how this is happening has clear benefit for effective public freight planning and management. Mapping of national freight flows with warehouse activity shown separately, which at an aggregate level has less exposure to confidentiality limitations, thus could be a valuable additional output of CFS raw data processing, both for understanding of the service provided by the national primary network, and the changes wrought between 2007 and 2012.

Next Steps

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The information presented in this circular captures an initial discussion of supply chain information and the potential for identifying and using many of its complex components to support and inform public-sector decision making. General themes were identified and encapsulated as the first step to identifying specific research needs. The anticipation is to coordinate integrating the supply chain concept into existing freight- and data-related activities, programs, and research while concurrently developing and expanding the themes presented in the circular into more developed research statements or programs as necessary to meet the intent of that theme.

FRAMING A RESEARCH AGENDA

A national research agenda could start with first accepting and building upon a simple grid of supply chain activities, such as shown below. This grid could be applied to organize thinking and planning around public-sector activities. For instance, consider the grid on page 24 as a basic tool for public sector planners at the local, state, or national level. They would first answer questions within their area of responsibility:

- Does my region host a freight hub(s)?
- Do those hubs have related highway connectors, rail connectors?
- Is the significance of my freight hub of a local, regional or national scale?
- Do these hubs or connectors require attention from my agency for infrastructure funding, traffic management, congestion or air quality relief, strategically important military moves, emergency preparedness, homeland security planning, etc.?
- Where do I find data to help me understand the throughput (volume) of my specific freight hub and its related connectors (see listed data sources in the section on Supply Chain–Related Data Sources)?
- What other agencies have knowledge or apply supply chain thinking?
- What private agencies can I talk to that have knowledge or apply supply chain thinking?

Example: Simple Grid of Supply Chain Activities "Applying a Supply Chain View"

	Local	Regional	Global
Freight Hub (seaport, rail yard, air cargo operation, border crossing, etc.)			
Intermediary Distribution Zone			
Freight Spoke: Highway Connector			
Freight Spoke: Rail Connector			
Freight Spokes: Highway or Rail Network (Apply a supply chain view. How does the freight hub link to the rail or highway network?)			

Examples of how to apply and use this grid include the following:

- Prepare state and regional freight plans: systems and policy planning;
- Evaluate corridor and project plans;
- Prepare economic development analysis;
- Support performance-based management;
- Educate elected officials, agency leaders, and others about how freight moves within their communities and states and what the corresponding impacts are;
- Support requests for legislative funding of freight transportation programs;
- Identify bottlenecks or deficiencies in the transportation system;
- Evaluate how specific public investments can assist local firms' logistics operations function more smoothly; and
- Support other activities as identified.

The section on Existing Supply Chain–Related Data Sources provides a discussion of existing tools and data which can provide an initial starting point for building out the grid.

SUGGESTED RESEARCH TASKS

- Build out the simple grid concept and discussion of uses and applicable data.
- Identify data needed to apply the supply chain view:
  - Determine what new data are necessary for public-sector requirements and
  - Consider how that supply chain data could be secured and distributed.
- Identify groups and organizations that might support a common supply chain approach to supply chain–related freight data:
  - Develop a more robust analysis of benefits to those groups and organizations and reach out to organizations such as
    1. American Association of Port Authorities,
    2. American Association of Railroads,
    3. AASHTO,
    4. American Metropolitan Planning Organizations,
    5. American Trucking Association,

6. Intermodal Association of North America,
7. National Association of Regional Councils,
8. U.S. Army Corps of Engineers,
9. U.S. Department of Commerce,
10. U.S. Census Bureau,
11. U.S. Department of Defense, and
12. Others to be identified, and

- Explore pooled research opportunities.

- Engage private-sector stakeholders:
  - U.S. Chamber of Commerce,
  - Council of Supply Chain Management Professionals,
  - Retail Merchants Federation,
  - National Manufacturers Association, and
  - Add others.
- Develop strategic research plan to advance the supply chain view to support public-sector activities.

Appendix

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