Current State of Estimation of Multimodal Freight Project Impacts

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As available data have increased and as the national transportation funding bills have moved toward objective evaluation, departments of transportation (DOTs) throughout the United States have begun to develop tools to attempt to measure the effects of different projects. Increasingly, DOTs recognize that the freight transportation system is necessarily multimodal. However, no DOTs have clearly stated objective tools with which to evaluate multimodal freight project comparisons. This paper informs that gap by summarizing the existing academic literature on the state of the science for the estimation of freight project impacts and by reviewing methods currently used by selected DOTs nationwide. These methods are analyzed to identify common themes to determine potential avenues for multimodal project evaluation.

Freight is an important component of any state economy, as recognized by the recent Moving Ahead for Progress in the 21st Century Act (MAP-21) transportation legislation, which has strongly emphasized the use of performance-based methods in all transportation programs. Accordingly, and as part of MAP-21 mandated statewide freight planning, many state departments of transportation (DOTs) have been assessing their freight transportation systems and are interested in understanding the impacts of freight transportation. Increasingly, DOTs also recognize that the freight transportation system is necessarily multimodal, involving movements of shipments on waterways, airways, and railways in addition to highways. Project evaluation methodologies are needed to compare the impact of potential investment projects across more than one mode.

As available data have increased and as the national transportation funding bills have moved toward objective evaluation, DOTs throughout the country have begun to develop tools to attempt to measure the impacts of different projects. Methodologically, these tools tend to use a benefit–cost structure (sometimes implemented as a consumer surplus model and sometimes referred to as cost–benefit), an economic impact model, or some type of ranking or scorecard method. Benefit–cost analysis (BCA) models look to quantify specific costs and benefits of projects, itemizing each component. Economic models generally attempt to identify specific economic impacts in regard to job creation or trade inducement and frequently take the form of economic input–output models. Scorecard methods allow for semiquantitative analysis of qualitative components along with quantitative measures.

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While various methods now consider freight projects, these methods are not necessarily suitable for multimodal investment comparisons. This paper will address the need for multimodal freight project impacts assessment by reviewing methods currently used by selected agencies nationwide and summarizing the existing academic literature on the state of the science for the estimation of freight project impacts. These methods are analyzed to identify common themes to determine potential avenues for multimodal project evaluation and tool development.

SURVEY OF GOVERNMENTAL INVESTMENT EVALUATION METHODS ACROSS FREIGHT MODES

This section provides an overview of methods various states and governmental organizations use to prioritize investment projects for freight. The list is not comprehensive; rather, the methods chosen for this in-depth review are well-documented and represent the state of the practice. A review of these methods serves to establish the state of the practice across modes. Planning documents and tools were reviewed. All state DOT websites were examined to identify planning and projection selection methods with thorough descriptions in the available documentation. The methods with sufficient detail were selected for further review. A sample of national, local, and regional efforts were included to ensure that different modes and project scales were represented, but an exhaustive review of these resources was not undertaken.

National-Scale Methods

FAA BCA (Air)

The FAA airport BCA tool allows FAA to make considered evaluations of proposed airport projects under the Airport Improvement Program (AIP). Evaluation with this tool is required for discretionary projects (it is not required for projects necessary to meet various standards) needing at least $5 million in AIP funding. The tool considers reduced delay for aircraft, passengers, and cargo; improved schedule predictability; more efficient traffic flows; use of larger, faster, or more efficient aircraft; safety, security, and design standard benefits; environmental benefits; and operating and maintenance benefits (*1*).

Discretionary Grants BCA (Multimodal)

Applicants are expected to estimate all project benefits that adhere to Transportation Investment Generating Economic Recovery (TIGER's) five long-term goals (livability, economic competitiveness, safety, state of good repair, and environmental sustainability). The guidance document suggests the following list of benefit categories to include as a starting point: types of societal benefits, land use changes to reduce vehicle miles traveled (VMT), increased accessibility, property value increases, travel time savings, operating cost savings, prevented accidents, deferral of complete replacement, maintenance and repair savings, reduced VMT from not closing bridges, and environmental benefits from reduced emissions (*2*). Benefits should address the extent to which "residents of the United States as a whole are made better off," and all included benefits should be clearly and directly tied to the funded project (*2*). Likewise, all costs associated with the funded project, not just the TIGER Discretionary Grant funds, should be included to ensure that all costs and benefits of a particular project are represented. Finally, once identified, all costs and benefits should be discounted to present values. The current prevailing government discount rate of 7% should be used, but a discount rate of 3% may also be included for comparison.

State-Scale Methods

Florida

Highway The Strategic Intermodal System (SIS) Investment Tool (SIT) was developed specifically for prioritizing highway capacity expansion projects and is available online with a framework allowing users to test the sensitivity of the results to the category weights (*3*). Twenty-four prioritization measures are identified, and each measure is assigned a weight depending on how it meets the five SIS goals of safety and security, system preservation, mobility, economics, and quality of life. The weights range from 1 to 10, allowing for an overall total score of 100 (*3*). Although this scorecard is suggested for multimodal investment prioritization on the SIS, it has been applied only to highway capacity project prioritization.

Rail In addition to the SIT tool, the Florida DOT has developed a process for the prioritization of rail projects (*4*). The rail plan includes five goals: safety and security, quality of life and environmental stewardship, maintenance and preservation, mobility and economic competitiveness, and sustainable investments. Twenty-three measures are associated with these goals including quantitative measures (e.g., crash reduction from auto and truck diversion, change in auto and truck fuel consumption and carbon dioxide emissions, and reduced travel time and vehicle operating costs) and qualitative measures (e.g., consistent with asset management approach, status of environmental screening process, and project underwent public review).

The state rail division uses the freight rail improvement calculator to calculate the benefits from certain individual freight improvement projects in the SIT tool. Macroeconomic impacts of these projects are calculated for the SIT tool by using the Highway Economic Requirements System (HERS) model and the Regional Economic Models, Inc. (REMI), model to calculate statewide development benefits from projects. Specific freight performance measures are used in these calculations, although some of these difficult-to-quantify measures are scored "yes" or "no." Their methodology is complex and includes estimates of benefits derived from a diversion of auto and truck traffic from highways. Despite this complexity, each scorecard presents the measures in an intuitive and easily interpretable scale of quality, from low to high (*4*).

Georgia, Multimodal

In Georgia, the fundamental metric for project evaluation is a cost–benefit analysis (CBA). Section 3 of the Georgia Freight and Statewide Logistics Plan discusses the methodology for evaluating individual freight improvement projects (*5*). For port and rail improvements, the evaluation relies on previous reports. For airport improvements, the CBA relies on "qualitative descriptions from discussions with airport staff." Highway projects rely on either the state DOT travel demand model or what is referred to as an " 'off-model' analytical technique" (*5*). A benefit–cost ratio greater than 1 is used as one threshold across modes for inclusion in the plan.

Maryland, Multimodal

The goals for evaluating freight projects in the Maryland Transportation Plan include quality of service, safety and security, environmental stewardship and development plan goals, connectivity for freight mobility, and coordination (*6*). The scorecard gives each of these goals a weight, ranging from 10% to 30%; the goals were developed iteratively by using feedback from the Interagency Advisory Committee, the Freight Stakeholder Advisory Committee, and other freight stakeholders. Detailed methodologies are provided for highway and rail projects. Port projects are scored by using professional judgment (*6*).

Massachusetts, Multimodal

Section 4 in the Massachusetts Freight Plan details the final list of proposed freight improvement plans (*7*). Each major freight corridor was evaluated for each freight mode: rail, air, highway, and maritime. Existing conditions were assessed by using a set of freight performance measures. The evaluation of investment projects includes a data collection process, a CBA, and an economic impact analysis, which includes direct effects, indirect effects, and induced effects.

The freight plan considers two scenarios of rail improvements, two scenarios of multimodal improvements (primarily connections between modes), and a truck highway improvement scenario. It considers total costs for each and then calculates a benefit–cost ratio by using direct, indirect, and induced benefits including environmental, congestion, time savings, and mode-switching impacts. It estimates that 75% to 92% of the benefits in four out of five of the scenarios accrue to shippers and carriers, and thus conclude that this situation justifies considering public–private partnerships. The Massachusetts DOT provides the in-depth methodology used to evaluate different aspects of the investment scenarios (beginning on p. 4.2).

Missouri, Multimodal

The Missouri DOT has a division of multimodal operations responsible for supporting alternative transportation programs in the state. This division includes strategic planning for aviation, rail, transit, waterways, and freight development. The Missouri DOT does not rank projects across modes, but it does use a standard framework for transportation planning and decision making, which was developed for prioritizing road and bridge projects and has been adapted for use on waterway investments (*8*). The staff is hopeful that this framework will be used for multimodal investment decision making, but it has not yet been refined for that purpose.

The framework involves scoring projects according to the perceived ability of the project to attain the various stated objectives and goals established by the Missouri DOT. Every project is intended to meet one of these goals, and each goal uses a unique scorecard. The scorecards are comparable by weighting the composite categories (e.g., projects intending to address the "safety" goal give 90% of the weight to quantified safety improvements and 10% to congestion relief components). Each category (access to opportunity, congestion relief, economic competitiveness, efficient movement of freight, quality of communities, environmental protection, safety, and take care of the system) has a total possible maximum score of 100 (*8*). Weights and point values for each transportation goal are determined by the Missouri DOT, regional planning organizations, and metropolitan planning organizations.

Oregon, Multimodal

Oregon has a detailed freight plan intended as a statewide plan for the multimodal system of freight transportation in the state. The plan "supports identifying, prioritizing and facilitating investments in Oregon's highway, rail, marine, air, and pipeline transport infrastructure to further a safe, seamless multimodal and interconnected freight system" (*9*).

The ConnectOregon program deals with nonhighway investment projects in Oregon and has a set of criteria for which each project is evaluated. The procedure includes no standard way to calculate impacts, such as the number of jobs created by a project. Thus, the impacts for each project and mode are estimated, and these measures have little consistency across modes or projects (*10*).

When a project is evaluated, the ConnectOregon program asks evaluators to consider whether the proposed transportation project

1. Reduces transportation costs for Oregon businesses or improves access to jobs and sources of labor,
2. Results in an economic benefit to the state,
3. Completes a critical link connecting elements of Oregon's transportation system that would measurably improve utilization and efficiency of the system,
4. Leverages funds by the applicant for the grant or loan from any source other than the Multimodal Transportation Fund, and
5. Meets construction-readiness standards.

The criteria above are evaluated "yes" or "no" and are not weighted.

Recently the Oregon DOT has been working on a least-cost-planning (LCP) framework as defined by the 2009 Oregon legislature. Accordingly, the LCP division has contracted to develop a tool to facilitate planning to meet this least-cost ideal. The tool, MOSAIC, is an Excel spreadsheet framework with monetary and nonmonetary measures to evaluate and compare potential programs including a range of projects. MOSAIC was developed by including input from the Statewide Transportation Improvement Program Stakeholder Committee, technical teams from the Oregon DOT, the Oregon Transportation Commission, and other agencies (*11*).

MOSAIC includes a section in which BCA is used to monetize values for benefits and costs of a particular program of investments by using monetary values and costs provided by the program. This approach provides results such as a benefit–cost ratio or the net present value of a set of investment projects. When assigning a monetary value is difficult, a point system is developed with the weights decided on by the stakeholder groups. The result is a combination of a BCA and a ranking and scoring system for prioritization (*12*).

The state of Oregon is interested in developing a method to do a side-by-side comparison of two projects from different modes to determine which will have the biggest impact. ConnectOregon has review questions for each project, and measures are identified as they move from mode to mode. The scales used change between modes, which makes intermodal comparison difficult.

Washington State

The state has a clear prioritization process for highway and rail improvements, but a comparative multimodal freight prioritization does not exist. The state has two entities responsible for evaluating freight projects: the Freight Mobility Strategic Investment Board (FMSIB) and the Washington State DOT.

Washington State does not currently have any way to directly compare projects across modes. Although a BCA is used, the ultimate decisions are made in consultation with public and private stakeholders and often a scorecard type of system is used. Because explaining BCA results to stakeholders and the public can be difficult, projects are frequently ranked with a scorecard approach.

Highway The FMSIB methodology for project selection combines scoring methods with stakeholder and committee input (*13*). The 10 criteria include benefit of freight mobility for the project area; freight mobility benefits for the region, state, and nation; general mobility benefits; safety improvements; freight and economic value to the region and the state; environment benefits including diesel emissions; partnership funding; consistency with regional and state plans; CBA; and special issues.

The Washington State DOT also evaluates highway projects but uses a more intricate process, by classifying projects into high- or medium-benefit categories. It identifies high-priority performance gaps documented in its surveys with shippers, carriers, and other stakeholders. The agency identifies bottlenecks, chokepoints, and safety issues on high-volume truck freight corridors that might be alleviated by proposed projects (*13*). The state is developing a detailed benefit–cost methodology to inform this process.

Rail The Washington State DOT freight rail BCA is applied to all Washington State DOT freight rail projects, including Freight Rail Assistance Program and Freight Rail Investment Bank Program projects. The standard methodology may be supplemented with additional benefit information, but any changes must be justified with adequate documentation. The Washington State DOT completes the BCA on the basis of information provided by the applicant, and the included benefits are transportation and economic benefits, economic impacts, external impacts, and yearly maintenance costs, which cover nine primary metrics: reduced maintenance costs, reduction in shipper costs–freight only, reduction in automobile delays at grade crossings, new or retained jobs, tax increases from industrial development, safety improvements, environmental benefits, track maintenance, and equipment maintenance (*13*). Quantitative and qualitative analysis techniques are used to document the project's logistics, resources, goals, and support of broad industry sectors.

The FMSIB uses the same method to prioritize highway and rail projects, thus making the comparison "mode neutral."

Air Although the research team did not identify a method used by the Washington State DOT to evaluate air investment, the agency does have a method to estimate airport economic impacts. This tool focuses on job creation and business attraction and does not include costs. Impacts are considered in regard to the airport, industrial community, and local community users to determine the economic benefit of an airport to the surrounding community (*14*).

Regional Methods

Puget Sound Region, Washington State, Multimodal

Vision 2040 is the region's long-term strategy for sustainable development, and the Transportation 2040 (T-2040) plan is one branch of this vision (*15*). T-2040 addresses freight and multimodal transportation as components to the overall mission. The Puget Sound Region in Washington State ranks projects with a scorecard method similar to that of Maryland's DOT, with the nine ranking components (air quality, freight, jobs, multimodal, Puget Sound land and water, safety and system security, social equity and access to opportunity, support for centers, and travel) each given a relative score of 1 to 5 (*16*).

Port of Portland, Oregon, Multimodal

National Cooperative Freight Research Program (NCFRP) Report 12 includes a case study of the port of Portland, Oregon, which operates air and marine ports in Portland along with industrial parks (*17*). The report outlines its project evaluation tool, which is used to organize the merits of the proposed projects, but not ultimately select them. Selection is completed by "a series of teams and commissions," and final responsibility lies with the port directors and port commission (p. 33). Prioritization depends on whether the project is critical to meet needs and is approved, whether it addresses a specific aspect of the business plan, or whether it is discretionary. Projects are grouped into four categories related to these prioritization levels: legal, regulatory, contractual, and mandate; maintenance and replacement; business development (discretionary); and indirect benefit to the port (benefits to the community or region).

METHODS AVAILABLE IN THE LITERATURE

In addition to the review of methods in use by agencies across the United States, methods reviewed or proposed in the literature were considered. This section outlines the findings.

Truck Travel and Highway Projects

National Review

Sage et al. completed a comprehensive review of the literature in regard to highway freight benefits and economic impact evaluation tools (*18*). Their work found that most currently implemented BCA tools quantify the benefits in relation to avoided crashes and reduced travel time (as measured by a number of different metrics) and the costs in regard to construction, operating, and user costs. Other important measures include reliability and economic impacts, though both are difficult to estimate. They identify that assigning a monetary value to travel time and reliability is a particular challenge for freight projects because of the many stakeholders, commodities, and supply chain types. Regular delays have costs different from that of unexpected delays.

Regional Method

Kim et al. rank freight projects in the Anchorage, Alaska, region according to subjective and objective criteria focused on travel time, congestion, and safety (*19*). Survey results from a variety of stakeholders indicated that congestion and ease of mobility were primary concerns. Ultimately they ranked projects by crash data, traffic volume, and survey evaluation and considered different weightings of each of these factors.

Rail Freight

National Review

As most rail infrastructure is privately managed, evaluations of publicly supported rail projects can be more complex. NCHRP Report 586 looked at using freight rail to address roadway congestion and in doing so, developed a framework for comparing the costs and benefits of both (*20*). One useful point made in this document is the differing nature of the costs between rail users and trucks—railroads are responsible largely for their own infrastructure costs and the costs of congestion while trucks share those costs with all roadway users. This report compares alternatives by using BCA. The following broad categories of measurement are suggested: congestion levels and reduction potential, shipping cost and service features, logistics costs, truck-to-rail diversion, and traffic and economic impacts. Benefits and costs are classified as being private, governmental, or public but nongovernmental, to allow evaluation from different stakeholder perspectives to address the differing cost burdens.

Regional Method

Transportation Economics & Management Systems, Inc., and HNTB looked into the impacts on the Midwest for investing in rail and relied on a benefit–cost tool and an economic input–output model (*21*). Benefits included reduction in travel times, emissions, and costs across modes because of congestion reductions and modal switch to rail. The authors considered highway and air as competing modes, so this project did have a multimodal component, though as with many projects, the focus was on passenger travel. Costs focused on infrastructure or capital costs, track maintenance costs, and operating and maintenance costs for the rail system. An economic rent model was developed to estimate the economic impacts from the project.

Multimodal Prioritization, Including Freight

National Review

NCFRP Report 12 looked at how to estimate benefits of freight projects to coordinate private-sector and public-sector investments and planning (*21*). The report identified four impact parties including those who own and maintain infrastructure, those who provide service, those who use infrastructure, and the rest of the community. It considered direct and indirect financial impacts as important along with other nonfinancial impacts. It identified pertinent costs and benefits including capital, maintenance, and operating costs along with reliability, mobility, safety and security, economic development and revenue, and environmental benefits.

In 2001 NCHRP Project 20-29(2) worked to develop a tool for multimodal, multicriteria transportation investments for freight and passenger travel (*22*). The resulting software, the Transportation Decision Analysis Software (TransDec), is currently available from McTrans, but no evidence was found of its being used by any DOT. The software allows consideration of the following goals and objectives (*22,* p. 3): improve mobility, improve connectivity, increase cost-effectiveness, increase energy efficiency, improve air quality, reduce resource impact, reduce noise impact, improve accessibility, reduce neighborhood impact, and improve the economy.

State Method

While developed to support multimodal investments in passenger travel, the Multimodal Investment Choice Analysis structure can be used to evaluate freight projects (*23*). This tool was developed for the Washington State DOT but has never been put into practice. The tool suggests having standard global variables for all projects and modal-specific variables that support evaluation of monetary and nonmonetary impacts at the project and scenario level. Monetary impacts are drawn from user operating impacts, environmental impacts, and safety impacts and are categorized as capital, operating, maintenance, and environmental costs assigned to DOT, federal, private, or local costs. Nonmonetary impacts include raw versions of the monetary costs (e.g., instead of calculating the financial impact of the total number of crashes, the total number of crashes itself is tracked) and the results of outcome objectives—qualitative concerns including communities, economic development, and environment, along with various statewide and multimodal outcomes and various service objectives.

Regional Method

Protopapas et al. developed performance measures to support multimodal freight comparisons between inland towing, rail, and trucking (*24*). The performance measures included cargo capacity, traffic congestion, energy efficiency, air quality, safety, and infrastructure and were developed per ton-mile to allow for modal comparisons.

RESULTS

Measurement Patterns Across Modes

The various goals and measures used in the methods above were compiled to identify common themes and determine whether they are sufficient for multimodal project evaluation. A summary of the methods is provided in Table 1. As illustrated, of the seven methods with enough detail to include in the summary, all but one consider congestion relief and safety and security in some form. Most of the methods also include measures addressing economics and competitiveness, environmental stewardship, connectivity for freight mobility, and land use or development patterns. Goals used by less than half the methods include system preservation or maintenance, freight-specific mobility, reduction to transportation costs, availability of external funding sources, and new or retained jobs.

Of the seven methods summarized in Table 1, five apply to highway projects, four to rail, and three to waterway projects. All of the highway methods incorporate some sort of mobility measure and safety and security, and all but one, environmental stewardship (Maryland's freight evaluation criteria) and land use and development plans (Florida's SIT). Three of the five methods include economics and competitiveness, connectivity for freight mobility, and freight-specific mobility.

No goal is incorporated into all of the rail methods, but nearly all of the same goals identified as common for highway projects are also common for rail projects (mobility, safety and security, economics and competitiveness, environmental stewardship, connectivity for freight, and land use and development plans). In addition, reducing transportation cost and being able to leverage external funding are also used by half of the rail methods. Few include freight-specific mobility, however. Economics and competitiveness is the only measure seen in all the water-project evaluation methods. The same goals common in highway and rail methods are common in the water methods, and as with highway methods, the water methods generally do not include reducing transportation cost as a goal.

Multimodal Evaluation

In regard to the state DOTs' resources, few DOTs indicated that they had a formal tool or methodology they used for comparing and ranking projects across modes. What methods they do use are either BCAs relying on simple, measurable values or some type of score or evaluation framework. The scorecard or evaluation frameworks (and some BCAs) outline goals that are consistent across modes but rely on different implementation methodologies for differing modes. Having different methodologies across modes is understandable since different modes have different challenges and advantages. However, these differences present challenges to applying an objective evaluation methodology. Safety and security for highway and air modes often are focused on the value of a fatality, injury, or property damage while rail and water modes, which involve fewer numbers of personnel, tend to focus more on security aspects or the value of avoided crashes on the highway. These differences reflect the differing operating characteristics of the modes.

Another common challenge in evaluating projects across modes is the need to develop weights for the measures. Here again, stakeholders for different modes have different priorities, and establishing consistent, objective weights across modes is a challenge. Many of the DOTs take stakeholder input to develop the weightings. The documentation is not clear on how often this process takes place or to what extent the weights are developed systematically.

Responses in the Literature to Identified Limitations

The methodologies outlined above all have some type of objective component, but generally all have limitations to systematic multimodal evaluation. The two biggest challenges are developing

TABLE 1 Summary of Goals and Measures Used in Highlighted Methods

	Location, Tool, and Mode		
Goal	Florida SIS Investment Tool Highway	Maryland Freight Evaluation Criteria Highway, Rail	Missouri Function Needs Prioritization Process Road, Bridge, Waterway
General mobility and congestion relief, may include freight-specific measures	Connector location, v/c ratio, truck volume, vehicular volume, system gap, change in v/c-LOS or interchange operations, bottleneck or grade separation, delay	Potential for project to reduce delay and increase reliability	LOS, daily usage, functional classification
Safety and security	Crash ratio, fatal crash, bridge appraisal rating, link to military base	Potential for project to provide a safer operating environment and reduce opportunities to compromise supply chain	Safety index, safety concern, safety enhancements
Economics and competitiveness	Demographic preparedness, private sector robustness, tourism intensity, supporting facilities	na	Level of economic distress, supports regional economic development plans
Environmental stewardship	Land and social criteria, geology criteria, habitat criteria, water criteria	na	Environmental index
Connectivity for freight mobility	na	Enhance connectivity between freight modes or improve access to clusters of freight-intensive industries, or both	Connectivity, complies with regional or local transportation plans
Land use and development plans	na	Reinforce the development of freight-related land uses within existing freight activity centers or direct new development to PFAs and sites with adequate infrastructure	Connectivity, complies with regional or local transportation plans
System preservation and addressing deficient conditions and maintenance	v/c ratio, truck volume, vehicular volume, bridge condition rating	na	Substandard roadway or bridge features, pavement smoothness, pavement condition, functional classification, daily usage (all vehicles), truck usage, bridge condition, exceptional bridge
Freight-specific mobility	na	na	Truck volume, freight bottlenecks, intermodal freight connectivity
Reduces transportation costs	na	na	na
External funding sources	na	na	na
New or retained jobs	na	na	na
Miscellaneous	Land and social criteria, geology criteria, habitat criteria, water criteria	Coordination: to fulfill the plans, programs, or goals of multiple agencies	Access to opportunity: vehicle ownership, eliminate bike and pedestrian barriers

NOTE: na = not applicable; v/c = volume-to-capacity; LOS = level of service; PFA = priority funding area.

Oregon ConnectOregon Nonhighway	Washington Freight Mobility Strategic Investment Board Highway, Rail, Waterway Corridors	Washington State Rail Benefit–Cost Rail	Puget Sound (Washington State region) Scorecard Highway	Number of Tools that Include Goal
na	General mobility benefits	Value of motorist time (usually function of average wages) multiplied by expected reduction in delay	Travel	6
na	Safety improvements	Estimated money saved by not having to make highway safety improvements	Safety and system security	6
Economic benefit to state	Freight and economic value to region and state	Estimated assessed property value after project multi-plied by property tax rate	na	5
na	Environmental benefits including diesel emission	Total distance traveled by trucks diverted to rail multiplied by standard environmental cost per mile	Air quality, Puget Sound land and water	5
Connects elements of Oregon transportation system that will measurably improve utilization and efficiency of system	na	na	Multimodal	4
na	Consistency with regional and state plans	na	Support for centers	4
na	na	Reduce maintenance costs, track maintenance, equipment maintenance	na	3
na	Benefit of freight mobility for project area, freight mobility benefits for region, state, and nation	na	Freight	3
Reduces transportation costs for Oregon businesses or improves access to jobs and sources of labor	na	Comparison of cost of shipping goods via rail versus truck	na	2
Funding other than multimodal transportation fund	Partnership funding			2
na	na	Average wages for the region from Bureau of Labor statistics multiplied by eco-nomic multiplier to gauge total impacts	Jobs	2
Ready for construction	Special issues, CBA	na	na	5

measures that can be applied across modes and developing weights sensitive to the different operating characteristics of the modes.

Measurement Development

The findings above highlight the importance of identifying useful performance measures for freight travel. Because of the highly complex nature of freight movements and the limited existing data, additional work is needed to identify freight performance measures and gather supporting data. For example, Ko's dissertation attempted to develop performance measures necessary to evaluate truck level of service (*25*). He identified truck travel time and variance, safety, and ease of mobility as critical for evaluating the usefulness of a roadway for truck access. This area is growing in attention and is a rich area in the literature, and many states have been developing performance-based measures designed specifically for freight transportation (*26*). NCFRP Report 10 also looked at performance measures for freight transportation, identifying data issues and relevant performance measures across freight modes (*27*). The report groups its performance measures into six categories: freight demand, freight efficiency, freight system condition, freight environmental impacts, freight safety, and adequacy of investment in the freight system. The report indicates that the variation in completeness of available data is a particular challenge to developing consistent and useful performance measures. However, the report indicates that data are generally available to support many of the key measures identified above, including crash data and emissions data.

Winterich et al. attempted to identify freight performance measures for urban goods movement that would allow the impact of projects on these movements to be incorporated in project prioritization (*28*). Despite efforts to reach approximately 50 private firms, the authors were able to solicit responses from only a small number. They indicated that most passenger-based mobility performance measures could be adapted for freight mobility performance. Urban congestion significantly affects carriers' decisions, though it can often be accounted for. This team suggests including the economic value of delay to specific commodities as a useful way to incorporate freight mobility in project prioritization.

Assigning a value of time to freight is one particularly challenging aspect of developing objective freight project evaluation tools. Freight movements involve many stakeholders and a wide variety of commodities, all with different values and time pressures. Gong et al. used the analytic hierarchy process as well as willingness-to-pay to estimate the value of delay to shippers to measure the effects of highway investment on the freight community (*29*). They further discuss challenges in assigning the particular costs of delayed transportation in the freight industry.

Assigning Weights

As mentioned above, developing weights in an objective manner to assign to the measurement categories is a particular challenge, especially when an attempt is being made to develop consistent weights across modes. Outwater et al. (*30*) examined the Puget Sound Regional Council's project prioritization method by using the analytical hierarchy process and conjoint analysis to weight various measures in the process via stakeholder input (*31*). This system allowed for a more quantitative approach to the development of weights but still incorporated stakeholder input.

CONCLUSIONS

Of the state DOT websites, few indicated that they had a formal tool or methodology they used for comparing and ranking projects across modes. Tools used to evaluate freight projects fell into three broad categories: some type of BCA, a scorecard approach with points assigned to various criteria and weights, or some combination of the two.

Some common themes arise in an evaluation of the project prioritization measures used. Of the seven methods with enough detail to include in the summary, all but one method consider some type of congestion relief or improved mobility goal. Most of the methods also include measures that address goals of safety and security, economics and competitiveness, environmental stewardship, connectivity for freight mobility, and land use or development patterns. Goals that are addressed in fewer methods include system preservation or maintenance, freight-specific mobility, quality of life, reduction to transportation costs, availability of external funding sources, value to cost considerations, and new or retained jobs.

Many project evaluation tools focus on roadway travel. Of the resources that provide insight into the evaluation of non-truck freight modes or how to compare the results between modes, a number of limitations have been identified, primarily the challenge to developing measures, not just goals, that can be applied across modes and the challenge in weighting those goals consistently across modes. A number of tools have been developed in the literature to address these concerns, but more work is needed.

Some states assign funding specific to individual modes, and that lack of funding flexibility is a major deterrent to using multimodal trade-off analysis to optimize resource allocation and ensure an efficient freight system (*32*). While some states assign funding specific to individual modes and have no need for multimodal project prioritization, many others have considerable flexibility in how projects are financed. Those other states are best positioned to use limited available funds most efficiently. As those states aim to develop freight project evaluation tools sensitive to multiple modes, they should consider the above findings.

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