PUBLIC TRANSPORT EVALUATION

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Abstract

Most public transportation investment and operation decisions are made by considering the benefits, costs and impacts of proposed actions. This process may be formal or informal. "Evaluation" is the formal, systematic process of calculating or estimating those factors. "Ex post" (backward-looking) evaluation measures impacts of existing projects and services, which makes it possible to optimize current efforts and learn lessons for future designs. "Ex ante" (forward-looking) evaluation calculates the expected impacts of proposed projects and services, which makes it possible to select the most efficient and effective choices among available decision options. For public transportation, evaluation is particularly important and complex because public transportation is a service operated for the public as well as an infrastructure investment. Several different kinds of measurement and modeling methods can be applied to evaluate public transportation projects and programs, depending on the context. They may be applied to assess the effectiveness of public transportation schemes in addressing transportation performance goals or to assess achievement of broader financial, efficiency, equity, environment and economic development goals. This chapter provides a framework for public transportation planners and operators to identify evaluation needs and approaches for addressing them.

Introduction

Evaluation is particularly important for the design, operation and funding of public transportation facilities and services. It is the means by which public or private funders can determine the efficacy of investing in public transport. It is also the means by which planners and operating agencies can determine how best to meet current and future funding and investment needs. (This approach can also be extended to consider unanticipated factors such as an economic downturn and pandemic.) In practice, evaluation is conducted for public transportation systems, facilities and projects around the world. There are numerous examples of evaluation topics relating to public transport worldwide; some examples are shown in Tables 1 and 2.

Table 1 Examples of ex post evaluation (examining actual impacts of public transportation services)

System ridershipand efficiency results		
	Stockholm metro	Börjesson et al., 2014
	Rail transit inIstanbul, Turkey	Özgür, 2010
	TCP bus service in Porto, Portugal	Costa et al., 2014
	Urban rail transit in china	Quinet, 2014
	Demand responsive services in Great	Davison et al., 2014
Technology implementation results		
	Smart cards in Trondheim, Norway	Welde, 2012
	Bus passenger information system In	Politis et al., 2010
Bus rapid transit (BRT) implementation, Ridership, and performance results		
	Johannesburg,South Africa	Venter, 2013
	Bogotá, Columbia	Hidalgo et al., 2013
	Ontario (Canada), Oregon and California (United States)	Niles & Jerram, 2010
	Bus-to-tramway conversion in Paris, France	Prud'homme etal., 2011
Local land and economic development impact of new rail transit lines		
	Twenty-five case studies in the United	Economic Development Research Group, 2016a
	London Jubileeline extension and Madrid Metrosur	Mejia-Dorantes & Lucas, 2014
	U.S. light rail stations in Phoenix	Kittrell, 2012
	Houston	Pan, 2012
	Dallas	Clower et al., 2014

Table 2 **Examples of ex ante evaluation**
(also referred to as "appraisal"; expected benefits of proposed new public transportation investments)

Economic development impact of proposed new BRT lines		
	Sydney, Australia	Weisbrod et al., 2016
	Hartford, US	Carstensen et al., 2001
Demographic and Economic development impact of proposed new light rail transit (LRT) lines		
	Durham, Ontario, Canada	HDR, 2010
	Minneapolis, US	Cambridge Systematics, 2012
	Utsunomiya City, Japan	Sato et al., 2018
Economic growth impacts of proposed new commuter rail lines		
	Toronto, Canada	Delcan Arup, 2010
	Boston area, US	Goody, Clancy & Associates, 2009
Cost-benefit ofother proposed transit lines		
	Crossrail in London, UK	Colin Buchannanand
	Skycabs inAuckland, New Zealand	Ceder et al., 2015
	B-line Rapid Transit in Toronto, Canada	Steer Davies Gleave et
	Blue Line Metroin Stockholm, Sweden	Cats et al., 2015
Cost-benefit of proposed public transportation system improvements		
	Bus retrofit in Tehran, Iran	Bose, 2019
Cost-benefit of proposed public transportation system improvements		
	Broader businesscase and feasibility for proposed BRT in Wellington, New Zealand	PwC, 2015
	Denver, U.S	Felsburg Holt & Ullevig,
Revenue and financing for public transit investment		
	Impact of COVID-19 on public transport funding needs	EBP, 2020

The studies cited in Tables 1 and 2 include evaluations aimed at a variety of different audiences or stakeholders, utilize a variety of different types and dimensions of analysis, apply a variety of different impact measures and analysis methods and are used to derive a variety of different conclusions. These elements of evaluation are shown in Figure 1. This chapter reviews each of these evaluation elements, discussing how they are used, with examples of their application around the world.

Figure.1 **Elements of the evaluation process**

Objectives and audience

Evaluation objectives Public transportation services and facilities can be evaluated in terms of their effectiveness in meeting stated goals or providing desired benefits or their efficiency in providing a return on investment (ROI). This can be reflected in measures of the actual effectiveness and ROI from past investments or current operations, or it can be calculated in terms of the expected future effectiveness or ROI from proposed or planned investments or operations. The goals may be improvement in transportation system performance measures or in broader economic, environmental or social impact measures (which are further discussed later in this chapter). Forward-looking evaluations are typically referred to as “appraisal” in the United Kingdom and Commonwealth countries.

For organizations that fund, plan or operate public transportation services and facilities, evaluation can serve any of four objectives:

1 *Public Information.* Evaluation can show stakeholders (including its riders, private or public funding agencies, taxpayers and the general public) how the public transportation agency is providing performance, benefits and value for the money being spent or invested.

2 *Operation.* Evaluation can help improve public transportation operations by providing information on how well existing facilities and services are doing in terms of providing desired or expected benefits. It can also identify where there are needs for further improvement to correct problems or otherwise optimize performance in providing benefit and value to stakeholders.

3 *Planning.* Evaluation can help improve plans for further improvement, including expansion or upgrading of service – by identifying which route, equipment and facility options are best for achieving desired new outcomes. Evaluation can provide performance, cost and benefit measures to drive long-range plans, short-term prioritization or analysis of project alternatives.

4 *Research.* For academic researchers, evaluation can improve knowledge by applying data analysis methods to test behavioral hypotheses. That work is fundamental in establishing an empirical basis for the previous three classes of practical applications.

Audience. The audience for public transportation evaluation may be the electorate, public officials and legislative bodies who are considering public transportation funding; transportation planning staff who seek to prioritize projects and decide among project alternatives; public transportation operating agencies, whose staff who are considering route or service options or stakeholders who wish to optimize desired transportation service outcomes or avoid undesired impacts on communities. Depending on the audience, different choices may be appropriate for the type of analysis to be conducted and the types of impact to be covered.

Unique aspects of public transportation evaluation. In pursing the objectives outlined previously, it should be noted that public transportation evaluation is often more complex and broader in coverage than the evaluation of road investment. There are two reasons for this. First, public transportation is fundamentally a service, whereas public roads are facilities. Public transportation typically involves an operator whose decisions control the level of service provided to riders, whereas roads merely provide a means of access for various passenger and freight service operators to make use of those facilities. For this reason, evaluation results for public transportation will depend on level of service characteristics (such as route coverage, service frequency and vehicle comfort and capacity, as well as revenue and cost recovery) in addition to the physical (throughput) characteristics of the road or rail facilities that they utilize.

Second, public transportation serves a distinct market that is usually narrower in spatial coverage and more skewed in socioeconomic characteristics than that of roads. Public transportation may be offered anywhere, but its service and use are often greatest in areas with a higher density of population and employment, visitor attractions or low-income households. This can increase the need to consider equity, economic development and quality of life outcomes in public transportation evaluation studies and perspectives of the various operator and stakeholder groups that care about them. Public transportation also provides substantial energy efficiency and environmental impact advantages over car driving, so those broader impacts also need to be recognized in an evaluation of public transportation investment. These distinguishing aspects of evaluation for public transportation systems can have implications for the type of analysis to be conducted, an area that is discussed in the following section.

Type of analysis

It is useful to classify the impacts (effects) of public transportation facilities and services into four classes: transportation systems, economy, environment and social/cultural communities. They are represented in the column headings in the following. Each of them can be evaluated in at least five different ways, which are indicated by the rows in Table 3.

Table 3 Classes of effect and types of analysis

Class of effect *Type of analysis*	*(A)* *Transportation*	*(B)* *Economy*	*(C)* *Environment*	*(D)* *Social*
Impact magnitude				
Cost effectiveness ratio				
Cost-benefit analysis				
Multicriteria analysis				
Role or contribution				

The five types of analysis and their uses for public transportation planning can be defined as follows:

Impact magnitude. Investment in public transportation facilities and services can lead to effects on factors that correspond to societal policy goals and concerns. They may include measures of transportation performance factors (such as riders, safety, costs and revenues), impacts on the economy (such as job and income), environmental impacts (such as tons of pollution and greenhouse gas emissions) and/or social impacts (such as equity and quality of life for future generations). While the units of measurement vary widely, impact studies provide a means of identifying and showing the magnitude of all positive or negative factors that can aid public discussion and planning for new facilities and services. In some cases, the analysis is required by regulation, such as environmental impact studies (which often include economic and social impacts). In other cases, a separate economic impact study and financial feasibility study may be undertaken. A U.S. review of public transit economic impact reports (Weisbrod et al., 2017) summarized 13 national guides and 44 local transit impact and benefit studies. In addition to covering impacts on the economy, many of these reports also included impacts on the environment, health, public finance, land value and land development.

Cost effectiveness ratios. When comparing alternative investment options, it can also be important to determine the effectiveness of the available alternatives in terms of achieving goals. In those situations, it is useful to calculate the ratio of the preceding impact factors relative to a project's capital and operating cost. In the United States, for instance, grant applications for federal government funding of proposed new public transportation infrastructure requires estimates of new trips, emissions reduction, energy use reduction and safety improvement – each divided by the capital and operating cost of the project (Federal Transit Administration, 2016).

Cost-benefit analysis. Cost-benefit analysis (CBA) is a classic form of economic analysis that measures the efficiency of investment. It is referred to in North America as benefit-cost analysis (BCA). Unlike the preceding types of analysis, this method of analysis comprises all the positive and negative impact factors and portrays them in a common money-denominated metric of either "net benefit" (calculated as benefits – costs) or as a "benefit/cost ratio". It has the additional advantage that it adjusts for timing differences, such as the fact that large capital investments tend to occur early in projects, while longer-term benefits occur later in the future. This is done by applying a discount rate reflecting the time value of money, enabling results to be shown in terms of a "present value". The process for calculating CBA on a multimodal basis (including public transportation as well as other modes) is laid out in manuals produced by various state and national transportation appraisal and evaluation guides (for example, Department for Transport, 2018; US Department of Transportation, 2020; Government of India, 2017; New Zealand Transport Agency, 2013). Litman (2019) provides a comprehensive overview of the wide range of possible benefit and cost factors that can be relevant for public transportation investment evaluation. Ferrell (2015) reviews public transportation CBA studies in the United States; Quinet (2010) reviews CBA studies for transport in France, while Jacobs Consultancy (2011) reviews CBA studies for small-scale public transport in the United Kingdom.

Standard CBA studies focus solely on transportation system efficiency, that is, how well the transportation system functions in terms of the volume, speed, cost and safety of movement. An extended form referred to as social CBA (SCBA) expands the analysis to also cover wider societal benefits that also affect non-users, such as reduction in environmental emissions and improvement in quality of life and/or economic productivity. Typical benefit factors used in standard CBA are shown in Table 11.4; these same factors tend to be used in all countries. The entire CBA concept has practical limitations, though, as some of the wider societal benefits are hard to monetize and CBA usually ignores distributional equity (e.g., effects on vulnerable populations and distressed locations), as well as intergenerational equity (e.g., effects for future generations). These limitations are particularly notable for public transportation investments that seek to address strategic social goals for improving community equity, local economic development and environmental sustainability (Hickman & Dean, 2017). For that reason, transportation agencies in many countries rate and evaluate proposed public transportation projects by supplementing CBA with a broader multicriteria analysis evaluation that encompasses social impacts – a method that is discussed next (see Mackie et al., 2014; Wallis et al., 2013). A critical review of CBA and the need for supplementing it with social impact assessment are discussed in Johansson et al. (2019).

Multicriteria analysis. Multicriteria analysis (MCA) is a method for ranking alternatives in a way that can capture all relevant social, economic and environmental impact factors while allowing for consideration of tradeoffs and achievement of desired public policy goals. This is done by portraying all impacts of interest in terms of whatever quantitative or qualitative impact measure is most relevant and available and summarizing them in a table (referred to in the United Kingdom as an "appraisal table"). Alternative options may then be rated or ranked by assigning an importance weight to each of the impact factors, either explicitly in a scoring system or implicitly via evaluation discussions. While MCA lacks the precision of CBA, it can cover all factors of interest for decision-making. MCA may supplement or include the CBA results. The term "business case" is sometimes used to refer to a form of MCA that considers legal, financial, institutional and organizational capacity and feasibility for a project, in addition to the broader impacts cited in Table 4.

Table 4 Factors in CBA for public transportation

Change in travel time for transit users, car drivers + passengers
Change in vehicle operating costs for car drivers, fares for transit users
Change in emissions of criteria pollutants and greenhouse gases
Change in crash costs

Source: UK Department for Transport, 2018

MCA is widely used for prioritization and ranking of competing projects for funding decisions, though the specific factors considered in MCA vary by agency. A UK example of MCA for an urban rail line is provided in Dean et al. (2018). Several U.S. states have adopted MCA-based scoring systems for prioritizing major highway and public transportation infrastructure projects (e.g., Virginia Commonwealth Transportation Board, 2017). In Switzerland, rail projects are evaluated using "NIBA", a form of MCA that supplements CBA with ratings for construction impacts (e.g., traffic obstruction), longer-term impacts on the quality of life (e.g., noise annoyance in recreation areas) and sustainability (e.g., use of non-renewable energy sources).

Table 5 shows the types of wider impact factors (beyond travel time and travel cost factors) that are commonly used for MCA. It shows that MCA in the United Kingdom and United States includes access, economic development, environment (air quality) and safety impact measures. However, the UK example goes further in also recognizing surface environment and service quality benefits. The U.S. example goes further in also recognizing freight (truck) flow benefits of moving more passenger cars off of roads.

Table 5 Factors in MCA for the United Kingdom and United States

Factors in MCA Appraisal Table for Public Transportation (UK Department for Transport, 2018)
Economy: business users + transportation providers, reliability impact, regeneration, wider impacts
Environment: noise, air, greenhouse gases, landscape, townscape,historic, biodiversity, water
Social: commuting and other users, reliability impact, physical activity, journey quality, accidents, security, access to services, affordability, severance, option and non-use value
Public Accounts: cost to transportation budget, indirect tax revenues
Factors in MCA Appraisal for U.S. State of Virginia (Virginia Commonwealth Technical Board, 2017)
Safety: fatal and injury crashes
Congestion Mitigation: peak period throughput, delay
Accessibility: access to jobs, multimodal travel choices, access for disadvantaged populations
Environmental Quality: emissions
Economic Development: freight tons affected, reliability, commercial + industrial development
Land Use Coordination (Urban Areas): efficient use of land

Economic contribution analysis. Economic contribution analysis is different from the preceding four types of analysis in that it does not portray the incremental benefit or impact of a proposed project but instead measures the role (or contribution) of an existing public transportation line or system in supporting the economy and wellbeing of a city or region. This kind of analysis is most commonly done in places where public transportation is not a dominant means of travel and local planning or operating agencies see a need to better inform the local population and decision-makers as to the value of supporting continuation and growth of local public transportation services. Examples from the United States include a national study (Economic Development Research Group, 2020) and a guide for local public transportation providers (Stein & Weisbrod, 2017), as well as individual studies for the public transport systems of Anchorage, Alaska (Goldsmith et al., 2006); Atlanta, Georgia (Clark et al., 2012); Dallas Texas (Clower et al., 2014); Philadelphia, Pennsylvania (Economy League of Greater Philadelphia and Econsult Solutions, Inc., 2013); Hampton Roads, Virginia (Economic Development Research Group, 2016b) and rural transit in Tennessee (Southworth et al., 2005). The difference between economic impact and economic contribution is discussed further in Watson et al. (2007).

Dimensions of analysis

There is a need to “frame” the evaluation in terms of its spatial coverage, time period coverage and measurement of outcomes and impacts to address the study objectives and concerns of the intended audience. This section examines the dimensions of evaluation and factors affecting them.

The space-time dimensionality of public transportation evaluation. Every evaluation has a distinct spatial scale associated with public transportation areas served and their associated areas of impacts, as well as a time perspective for analysis. Table 6 illustrates the interaction of project spatial scale and time dimension.

Table 6 **Time–space dimensions of evaluation**

Spatial scale time perspective	*System (city or region scale)*	*Service (corridor scale)*	*Station/facility (neighborhood scale)*
Past (ex post)			
Current (ex post)			
Future proposal (ex ante)			

Time period. Ex post evaluations are limited to measurement using available current and historical data, plus information available from interviews. Ex ante evaluations depend on either predictive models or case studies of comparable situations; both sources build on information compiled from observed (ex post) research. For both forms of evaluation, it is important to recognize an appropriate time frame for impacts to occur. An overly short time period (e.g., less than five years following completion and opening of a public transportation facility or service) may not capture larger long-term impacts on transportation, land development and economic growth. For ex ante evaluation, a 25- to 40-year time frame is common to capture growth over the useful life of the investment based on forecasts from transportation and economic impact forecasting models. For ex post evaluation, the time period can be limited by how far back it is possible to go and still acquire time series data and interviewees knowledgeable about initial conditions. Notably, there are national database systems for assessing the impacts of major public transportation investments in both the United States (AASHTO, 2019) and France (Bonnafous, 2014).

Spatial scale. It is important to match the scale of evaluation to the scale of the public transportation element which is its subject, for instance, to consider change in pricing or service levels occurring across an entire metropolitan area. The impact of that change may be studied at the metropolitan level, or it can be studied in terms of a specific subset of it, such as impacts on particularly vulnerable neighborhoods or population groups. On the other hand, a change in a single bus line serving a specific part of a city needs to be studied in terms of how it affected its area of influence (over time or compared to adjacent areas). If the study looks at an overly broad regional impact area, it is quite possible that effects will be hard to discern, as localized impacts will be diluted by inclusion of other areas that were not affected by the change. The types of available economic impact data and analysis models also vary at different spatial scales – a matter discussed later in the context of economic impact measurement.

Setting a base case. Most evaluations need a basis for comparison to measure impact, which is commonly referred to as a base case or “counter-factual” case. So, for example, the impact of an existing light rail line (an ex post analysis) can by analyzed by comparing it to what would have occurred if the light rail had never been built. Similarly, the impact of a proposed new light rail line (an ex ante analysis) can by analyzed by comparing it to what would be expected to occur without it. In both cases, the comparison is to a scenario in which the light rail line was not built (in the past) or will not be built (in the future). Since that is counter to the facts that are assumed for the light rail line impact analysis, it can be referred to as a “counter-factual” case. In some cases, the counter-factual (base) case may be defined as “social, economic and environmental do nothing”, though in many other cases, it may be more realistically defined as “business as usual” or “continuation of current trends”. For instance, the most realistic base case for an evaluation of a proposed light rail line may be to have a bus route rather than just having neither. Since the definition of a base case can change the evaluation findings, care is required to appropriately define a realistic base case for an evaluation.

Impact measurement.

Impacts are typically measured in terms of "outcomes", which can be either direct impacts on travel conditions or consequential (indirect) impacts on the economy, the environment and/or social (community) functions. Depending on the audience, some or all of these classes of outcome may be included in an evaluation. The measurement of each of these classes is summarized in the following.

Transportation performance impact measures. A public transportation improvement may affect mode choice, in-vehicle travel time, out-of-vehicle wait and walk time, travel cost, reliability, comfort, safety and accessibility to desired destinations. These impacts may be measured from either or two perspectives: for public transportation users or for users of all modes of travel. For instance, a rail transit improvement may make travel faster and more reliable for existing public transportation travelers and for those switching from car to public transport. However, in many cases, mode switching leaves fewer cars on the road, so even those who still drive may find less congested and faster travel on highways. Hence, car travel benefits are often also considered a class of benefit associated with public transportation improvements. Some studies also distinguish impacts on enabling mobility for persons who would otherwise lack access or use of a car or other means of mobility.

Economic impact measures. The term "economic impact" correctly refers to effects on the economy of an area, which can occur as a consequence of project capital and operations spending or transportation impacts on productivity, household and business spending patterns and consequential effects on inward investment and business growth. This is in contrast to "economic benefit", which refers to the valuation of transportation system benefits as well as wider social, environmental and productivity benefits that may be considered in a social CBA; this is discussed further under "Social Benefits" subsequently. A related concept is "economic contribution", which refers to the current role of public transportation in supporting jobs and income in the economy. Economic impact studies typically report on results in terms of various measures or dimensions of economic growth, listed in Table 7. It is important to note that these measures are highly related and are thus not additive. The difference between economic benefit and impact measure is further discussed in Weisbrod et al. (2016, 2017).

Table 7 Elements of economic development growth from public transportation

Business revenues from capital and operations spending
Household transportation cost savings, which lead to changes in local spending and revenues
Household car ownership savings, which lead to further changes in local spending and revenues
Business operating cost savings, affecting economic competitiveness and market share growth
Business productivity from agglomeration and scale economies
Inward investment generating further business growth
Regional population and economic growth enabled by eliminating local capacity constraints

Source: EBP, 2020

The evaluation of a public transportation improvement plan, long-range plan, new service or new line may have impacts on the economy at the scale of a city, metropolitan area or broader region, depending on the specific case. In general, economic impacts are usually determined using a dynamic regional economic simulation and forecasting model that calculates effects on jobs and income generated in the applicable area economy over time. Income may be measured in terms of worker wages, household income, value added, gross regional product (GRP) or gross output (also referred to as "business sales" or "revenue" in North America or "turnover" in the United Kingdom and Commonwealth nations).

At a regional scale, economic impacts typically occur as a result of transport-related cost savings and additional business productivity gains from scale economies associated with wider labor and customer market access. Those direct effects may be counted as wider economic impacts in a social CBA, discussed subsequently. However, they lead to further macroeconomic effects that are not counted in CBA but may be calculated using a regional economic simulation and forecasting model. They are: additional jobs and income generated as households use their transportation cost savings to spend more money on other local purchases and additional job and income effects generated as business productivity gains translate into greater competitiveness, more inward investment and business activity growth. Examples of regional economic impact modeling studies for public transportation systems include Sydney, Australia (Weisbrod et al., 2016); Hartford, U.S. (Carstensen et al., 2001); Durham, Canada (HDR with Economic Development Research Group, 2010); Minneapolis, U.S. (Cambridge Systematics, 2012); Toronto, Canada (Delcan Arup in Association Economic Development Research Group, 2010) and Boston, U.S. (Goody Clancy & Associates, 2009).

At a local neighborhood or community scale, such as new stations along a new or extended BRT or rail transit line, the most applicable economic impact can be effects on land values and land development in the affected neighborhood(s) or along a corridor. There is a strong body of ex post research documenting how property values rise in proximity to public transportation lines and particularly around stations that serve high-frequency bus, BRT or rail transportation services. Ex ante evaluations also use case examples and models built on those examples to estimate expected effects of a new public transportation line or station. Examples of studies of the impact of light rail on property values include Phoenix, U.S. (Golub et al., 2012), and Dallas, U.S. (Clower et al., 2014). Cases studies of the broader social, environmental and economic benefits of BRT systems are presented in Carrigan et al. (2013).

Economists note that land value impacts are the "capitalization" of access and travel time benefits that reflect the household cost savings and business income potentials of land near stations, while new development near stations is the "manifestation" or consequence of that benefit. They also note that increased land value and land development near a station typically reflect a shift in demand away from sites further away (that may lose value and development). Thus, while the local benefit is real and may be desired by local leaders and stakeholders, the broader regional benefit may be lower due to losses elsewhere. Overall, land value impact is a valid measure of public transportation benefits; it must be reported separately and not added to measures of regional income gains to avoid double counting of benefits.

A final aspect of economic impact is revenue impact. All changes in public transportation ridership will mean changes in revenue for operators and owners, and all changes in land values and land development will mean changes in either wealth or income for property owners. Both may affect revenues and expenditures for government agencies, and those changes may also be calculated over time in a "financial evaluation".

Environmental impact measures. A public transportation improvement is likely to reduce both local pollution and global greenhouse gas emissions, as long as it enables a mode shift away from the private car. There are sophisticated air quality impact models that can be applied for detailed environmental impact evaluation. However, for simpler evaluations, it is possible to rely on widely accepted "rule of thumb" emission factors that represent tons of pollutants (NOx, SOx, particulates) and greenhouse gas (carbon dioxide) emissions per 1000 vehicle-km or vehicle-miles of travel. There are also widely accepted factors for the money valuation per ton of these various types of emissions. This enables the inclusion of pollution and greenhouse gas emissions in CBA.

Social benefit measures. Public transportation investment can provide many non-user benefits; some can be represented in terms of money value measures (as required for Social CBA), while others can only be represented by non-money measures (as appropriate for cost-effectiveness or multicriteria analysis).

Besides the value of emissions reduction, money value measures can also include business productivity gain from enhanced access. That is commonly referred to as "wider economic benefit" (WEB), and it is an element of regional economic impact. To estimate this benefit, transportation network and spatial economic models are typically required. Impacts on improving quality of life can sometimes also be valued in money terms, based on changes in land values that come from reductions in noise, smell, visual blight and/or access to community institutions.

Equity benefits may include socioeconomic, spatial and temporal (intergenerational) equity. It is very difficult to assign a money value to them, so they are most often considered in multicriteria analysis. This approach can consider impacts on reducing distributional disparities in access to health care, education and job opportunities among neighborhoods and communities. Equity can be improved by targeting services to:

- provide greater mobility to vulnerable populations of elderly and low-income households who lack access to a car or other means of access for health, education, recreation and shopping;
- provide greater access to well-paying jobs in areas where income levels are below average and unemployment is above average; and
- support investment in the development and enhancement of housing and commerce for populations in areas that have historically been economically blighted by insufficient new private investment.

An MCA evaluation process can identify areas of specific need along these lines and then assess the extent to which proposed public transportation improvements can serve to address those needs.

Business case analysis: enabling factors. While evaluation focuses on assessing either past or expected future achievement of desired benefit and cost outcomes, it can also recognize the role of context factors that can increase or reduce the likelihood of those outcomes being achieved. For instance, those factors may be considered in an expanded "business case" assessment for a public transportation investment in the UK (Department for Transport, 2013). Those factors may include:

- *Legal context:* Is legal authority in place for funding, building and operating the desired public transportation service?
- *Institutional and organizational context:* Are there institutions and organizations with the capacity desired to develop and operate the desired public transportation service?

- *Financial capacity:* Is there a way to raise up-front capital and maintain cash flow for public transportation service operation?

Concluding discussion

Evaluation for public transportation can inform five different processes: funding decisions, selection of the best alternative among options, prioritization of projects to be implemented, insight for project and policy planning and monitoring of results to improve future public transportation services. The relevant audiences may be public transportation operators, funders, planners, regulators, or other public and private organizations or individuals with a stake and interest in these processes. Since stakeholders may represent many different perspectives and interests, it is critical that evaluation be done in a manner that can provide the full range of desired information about transportation outcomes and their economic, social and environmental impacts. The breadth of evaluation methods and analysis elements that are covered in this chapter relate to many forms of impact associated with public transportation and its function as a social service as well as a transportation mode and a type of public investment.

The evaluation process has progressed substantially over a period of more than 50 years since Beesley and Foster (1965) calculated benefits and costs of the then-proposed Victoria line in London. In particular, there has come to be a more advanced understanding of the need to recognize the additional role of public transportation in addressing social, environmental and economic development goals and aspirations, as well as the economic efficiency of investment. The development of methods for addressing wider economic benefits, multicriteria analysis and the business case perspective are consequences of this evolution. A common theme is recognition of the need to explicitly recognize strategic public policy goals and evaluate the extent to which public transportation actions serve to achieve them (Berechman & Paaswell, 2005; Hale, 2011).

In the future, multi-perspective views may also be embraced as a way to recognize that public agencies, private interests, local communities and national agencies may each view certain benefits that are not recognized as benefits by others. In these cases, a multijurisdictional project may not rise to the top from any single perspective but may make collective sense if costs are allocated among the various public and private interests and jurisdictions. In any case, evaluation will remain fundamentally important to show the range of relevant impacts and benefits associated with any public transportation project or policy.

Future research, building on enhanced datasets, should provide substantially improved measures of accessibility and equity that will make it possible to more comprehensively measure the socioeconomic benefits of public transportation improvements. To accomplish this, there will be a need to develop better information on various income and age strata and their relationships to neighborhood location, car ownership, public transportation reliance, employment and the economy. New research of this type should ultimately enable more comprehensive evaluation processes that will help improve public transportation service as well as the measurement of its economic and social benefits.

As a final note, as this chapter was written before the announcement of the COVID-19 pandemic, this paragraph offers an addendum with respect to evaluation of public transport schemes. While the global COVID-19 pandemic has had immediate negative impact on public transportation ridership and revenue, there are broader implications affecting economic evaluation. One is the prospect of lingering impacts on revenue and finance for public transportation providers. Economic evaluation of future scenarios provides a means for estimating upcoming transportation finance needs for public policy decision-making (e.g., see EBP, 2020). There are also broader long-term implications for public transportation demand, as the pandemic has heightened public awareness of service quality issues, including crowding, comfort and health, as well as those of alternatives such as car and bicycle. These changing public preferences and concerns can be reflected in revised evaluations that reconsider the economic efficiency and social benefits of additional investment to further improve future public transportation facilities and services.

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