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Critical Analysis of Conventional Transport Economic Evaluation

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Abstract
Transportation economic evaluation refers to the process of quantifying and monetizing a transport policy or project's benefits and costs. How it is performed can significantly influence transport planning decisions. This report critically examines conventional evaluation practices. Conventional transport economic evaluation primarily monetizes changes in vehicle travel speeds and operating costs; it overlooks other impacts and objectives (parking costs, vehicle ownership costs, mobility for non-drivers, public health, and induced travel impacts), and other accessibility factors (the quality of transport options, roadway connectivity and geographic proximity). It seldom measures the economic efficiency gains from strategies that favor higher value trips and more efficient modes, or the consumer surplus benefits of accommodating latent demand. This analysis indicates that conventional transport economic evaluation has significant omissions and biases that favor mobility over accessibility, and automobile travel over other modes. Various reforms described in this report can result in more comprehensive and multi-modal evaluation.

Introduction

Transportation systems are partnerships between governments and users: governments planning decisions determine the transport options available, from which users choose the combination that best meets their needs. This report investigates whether commonly-use transport planning practices result in the set of options that best meet user and community needs. In particular, it investigates whether conventional evaluation practices are biased in ways that favor mobility (increased traffic speed) over other planning objectives, and automobile travel over other modes.

Transportation economic evaluation refers to the process used to quantify and *monetize* (measure in monetary units) a transport policy or project's *impacts* (benefits and costs). How such evaluations are performed can significantly influence planning decisions: a policy or project may seem desirable using one evaluation framework but undesirable according to another.

This is a timely issue. Conventional transport economic evaluation methods developed during a period when vehicle travel was growing rapidly so transport planning consisted primarily of roadway expansion. These methods were suitable for answering relatively simple questions, such as whether a highway project can repay its construction costs through travel time and vehicle operating cost savings. They consider a relatively narrow range of modes, objectives and impacts, and so are unsuited for evaluating the more complex tradeoffs required for urban transport planning and strategic policy analysis. Economic evaluation is just one part of the transport planning process – decisions are also influenced by political factors, public input and funding practices, and many transport modelers, planners and economists are working to develop more comprehensive and multi-modal evaluation methods, but these improvements are incremental; there are still significant omissions and biases in most evaluation frameworks. It is important that people who use evaluation results understand these problems.

This report investigates these issues. It critically examines transport economic evaluation methods, identifies their omissions and biases, and discusses how these are likely to affect transport policy and planning decisions. It identifies specific ways to make transport evaluation more comprehensive and multi-modal. This critique should be of interest to anybody involved in transport economic evaluation and planning.

The Conventional Evaluation Framework

An *evaluation framework* defines the analysis scope, that is, the impacts, objectives, options, activities, geographic area, and other factors that are considered in the evaluation process. *Impacts* can be defined as *problems* (what you don't want) or their opposite, *goals* (general things that you ultimately want) and *objectives* (specific ways to achieve goals). For example, if crashes are a problem then safety can be considered an objective, and reducing crash rates can be considered an objective. The terms *problems* and *objectives* are more qualitative, *costs* and *benefits* are more quantitative, as illustrated below.

Table 1 **Ways to Describe An Impact**

	Negative	Positive
Qualitative	Problem	Goal/Objective
Quantitative	Cost	Benefit

Cost, Benefit, Problem and Objective are different ways to describe an impact.

Conventional transport economic evaluation uses relatively narrow scope: it primarily considers government costs, travel time (and therefore congestion delay), vehicle operating costs, plus crash and emission rates (Markow 2012; SHRP 2012; TEC 2012). Table 2 summarizes the scope of various evaluation tools. Although none is truly comprehensive, some newer tools (TREDIS, PECAS and RUBMRIO), consider a broader range of impacts (Weisbrod and Reno 2009).

Table 2 **Transport Economic Evaluation Tools** (Ellis, Glover and Norboge 2012)

						BEA	EDR	TTI		FHWA												UT			
	AASHTO MANUAL	CDSS	EMME3	IMPLAN	REMI	RIMS II	TREDIS	HEEM-III	MicroBENCOST	HERS-ST	TELUS	TELUM	FHWA HWY 1	SCRITS	SMITE	SPASM	STEAM	REIMHS	REIMS	MEPLAN	PECAS	RUBMRIO	HEAT	TEIM	LEAP
TYPE OF PROJECT USED FOR:																									
Upgrade Existing	x						x	x	x	x	x	x			x						x				
Maintain Existing							x	x	x								x	x			x	x			
New Construction	x						x	x	x		x	x				x	x	x		x	x	x	x		
SCALE:																									
Specific Site				x								x				x				x					
Specific Corridor	x							x	x	x	x	x			x	x	x	x							
Region						x		x		x	x	x	x				x				x	x	x		
USER IMPACTS:																									
Money cost of travel	x							x	x	x	x				x			x			x		x		
Travel time	x	x	x				x		x	x	x					x	x						x		
Safety	x						x		x	x				x			x								
Comfort																									
Traffic volumes and average speed			x				x			x				x			x								
Calculation of delay savings							x										x				x		x		
Accident reduction savings	x							x	x	x															
Calculation of motorist benefits over the analysis period							x	x													x				
Highway improvement cost	x									x					x	x		x			x		x		
Summary of benefits and costs	x						x	x		x				x	x	x					x		x		
ECONOMIC IMPACTS:																									
Employment					x		x				x	x	x							x	x	x	x		
Wages		x			x		x				x	x	x							x	x	x	x		
Property values, prices or rents	x											x								x	x	x	x		
Business sales volume						x	x															x	x		
Value added						x	x				x									x					
Business profit						x															x	x	x		
Improved efficiency in public and private services															x	x	x			x		x	x		
Health and safety improvements														x											
Tourism spending			x																				x		
Number of establishments (new, existing, dislocated)												x										x			
Population/growth rate																									
Capital investment						x									x		x			x	x		x		
Building permits, construction activity																							x		
Value of oil and gas production																									
Usable parking spaces																									
Number of customers per day																									
Parking capacity influences on gross sales impacts																									
GOVERNMENT FISCAL IMPACTS																									
Public revenue/ taxes					x	x	x				x						x	x			x	x			
Public expenditures					x											x				x	x	x			
OTHER IMPACTS:																									
Air quality	x				x											x	x								
Social conditions	x				x		x							x	x					x	x	x			

This table summarizes various tools used to evaluate transport policy and project economic impacts. Note that many (CDSS, HEEM-III, LEAP, MicroBenCost, REIMHS, REIMS and SPASM) are outdated and should not be used, others (SMITE, SCRITS and Highway 1) are very specialized, HEAT is an example of a state-specific REMI shell program (other states have similar versions) and EMME3 is an example of a travel demand forecasting model, not an economic model.

The box on the following page describes the general capabilities and limitations of the various types of models.

Choosing Economic Analysis Software – Overview of Model Tools
By Glen Weisbrod, Economic Development Research Group (www.edrgroup.com/library/economic-impact-analysis/overview-of-economic-impact-models-a-tools-for-transportation-analysis.html)

Input-output (I-O) models calculate the economic development impacts (jobs, income and GDP) resulting from changes in regional business activity. For instance, they can be used to calculate the impacts of a new or expanded airport, power plant or construction activity. However, they have no long-term forecasting dimension, and no internal ability to forecast impacts of changes in transport costs or market access. For the US, the most commonly used RIMS-II and IMPLAN. For Canada, Statistics Canada offers provincial level models. More specialized models are also available.

Economic impact forecasting models are more comprehensive evaluation tools that calculate changes in business attraction as well as growth. They incorporate I-O models and add capabilities to calculate the economic growth consequences of changes in household and business costs (due to travel time and travel cost changes). Newer ones also calculate impacts of changes in market access and trade over time. For the US and Canada, the most commonly used are REMI and TREDIS. Both are multi-regional, spatial economic models that can also tax revenue impacts and social benefit-cost measures. Other models with more limited or specialized uses are also available.

Land use models forecast change in the location patterns of population, employment, housing and business activities. The newer versions are sometimes referred to as *spatial input-output models* because they base their allocation of business growth on I-O models, with greater spatial detail and less industry detail. They account for market access but not business attraction, because they assume fixed regional growth. Examples of land use models in current use are TRANUS, MEPLAN, MetroSim, UrbanSim, Delta and PECAS.

User benefit/cost models are designed to help engineers and planners identify, rate and select optimal highway projects. They assess highway improvement benefits travel speed and delay, safety, and sometimes emissions rates. They do not consider economic development impacts, although some of their impacts are incorporated into forecasting models. BCA.net provides project level analysis. HERS-ST assesses statewide highway investment needs and project priorities. LCCA evaluates facility lifecycle costs. Other widely recognized benefit-cost tools used by state DOTs are CalBC and NetBC. A variety of other transportation planning tools are also available.

Economic development tools are models and datasets designed to assist in business attraction and site location decisions. BizCosts, LocationSelector and FacilityLocations, Site Selector Pro and LEAP all compare alternative locations in terms of business operating costs, market conditions, labor force, land, transportation access, etc. They can assist businesses in making site location decisions for new facilities, and economic developers can use them to identify relative their area's strengths, weaknesses and best targets for business attraction. They generally consider transportation access in limited terms, such as distance to nearest interstate highway and airport.

Critique of Conventional Evaluation

This section investigates how well conventional evaluation considers various impacts and factors.

Comprehensive Evaluation

To provide accurate results, economic evaluation must consider all significant impacts. Table 3 indicates the degree that various planning objectives are considered in conventional evaluation.

Table 3 **Transport Planning Objectives**

Objective	Consideration In Conventional Evaluation
Congestion reduction, increased mobility	Generally considered – often a dominant impact
User convenience and comfort	Sometimes considered in roadway planning to justify paving, and in transit planning to increase ridership, but not generally considered an end itself
Roadway cost savings	Generally considered
Parking cost savings	Often ignored in transport planning but considered in other types of planning
User cost savings & affordability	Vehicle operating costs and transit fares usually considered, but vehicle ownership costs are often ignored
Disadvantaged people's accessibility	Universal design and basic public transit services are often considered planning objectives, but other impacts on disadvantaged people's access is ignored
Traffic safety	Generally considered, but measured per vehicle-mile,
Energy conservation	Sometimes considered, but measured per vehicle-mile
Air emission reductions	sometimes considered, but measured per vehicle-mile
Efficient land use	Not generally considered in individual transport plans
Public fitness and health	Not generally considered in individual transport plans

Only a portion of common transport planning objectives are considered in conventional evaluation. Some impacts are measured per unit of travel which ignores the incremental costs of induced vehicle travel.

Table 4 summarizes the results. Several potentially significant impacts are often overlooked. These overlooked impacts are sometimes called *intangibles*, with the implication that they are difficult to measure and modest in magnitude, and so can be legitimately ignored. However, they can be quantified and are often significant compared with commonly considered impacts (Litman 2009). For example, UK and New Zealand transport agencies provide guidance on methods for monetizing parking costs, habitat preservation, changes in mobility options for disadvantaged people, changes in public fitness, and option value (DfT 2006; NZTA 2010).

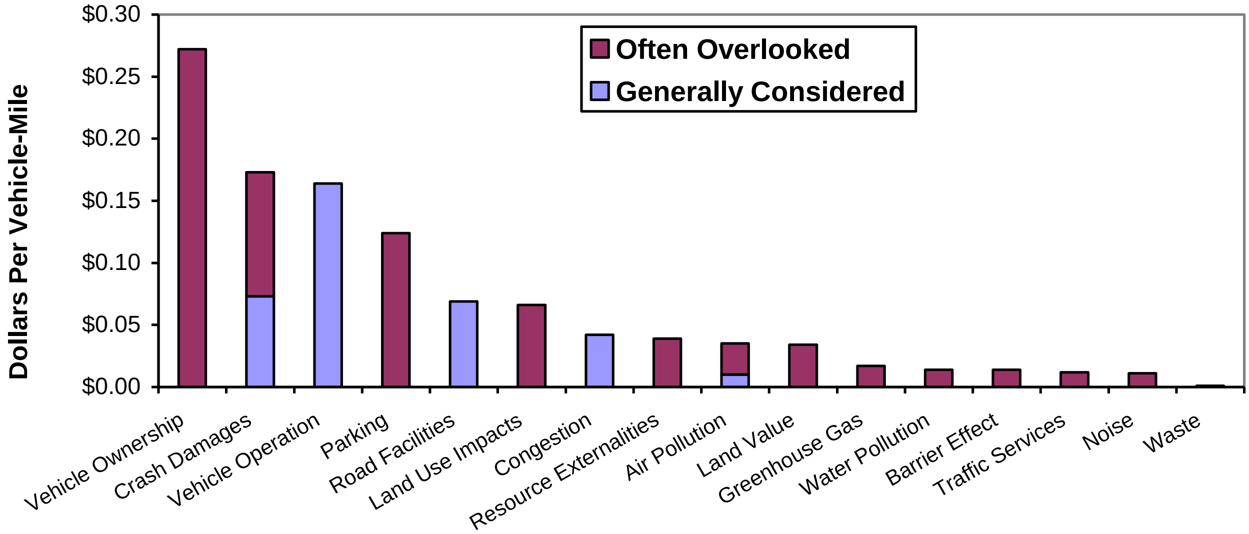
Table 4 **Impacts Monetized in Conventional Transport Economic Evaluation**

Usually Considered	Often Overlooked
Financial costs to governments	Downstream congestion
Travel speed (reduced congestion delays)	Parking costs
Vehicle operating costs (fuel, tolls, tire wear)	Vehicle ownership costs
Per-mile crash risk	Disadvantaged people's accessibility
Project construction environmental impacts	Delay to non-motorized travel (*barrier effect*)
	Noise and water pollution
	Strategic development impacts
	Public fitness and health

Conventional transportation economic evaluation tends to monetize a limited set of impacts.

Figure 1 illustrates the estimated magnitude of various impacts. Many of the often-overlooked impacts are significant in magnitude compared with impacts that are generally considered. For example, conventional evaluation generally ignores vehicle ownership, most parking costs, some accident costs (crashes that result from induced vehicle travel), land use impacts, resource externalities (fuel production economic and environmental costs not borne directly by users) and roadway land value (the value of land devoted to road rights of way), all impacts that are relatively easy to monetize.

Figure 1 **Automobile Costs** (Litman 2009)



Conventional transport economic evaluation generally considers congestion, roadway, vehicle operation, and some accident and air pollution costs. Other impacts are often overlooked.

Effects on Planning Decisions

These omissions can significantly affect planning decisions (Henderson 2011). For example, ignoring vehicle ownership and parking costs tends to significantly undervalue planning decisions that allow households to reduce their vehicle ownership, and ignoring objectives to improve accessibility for non-drivers and increased public fitness and health undervalues walking, cycling and public transit improvements.

Needed for More Comprehensive Evaluation

Comprehensive and multi-modal evaluation should quantify, and as much as possible monetize, all significant impacts, including downstream congestion, parking costs, vehicle ownership, delay to non-motorized travel (*barrier effect*), noise and water pollution, impacts on disadvantaged people's accessibility, option value, strategic development impacts and public fitness and health.

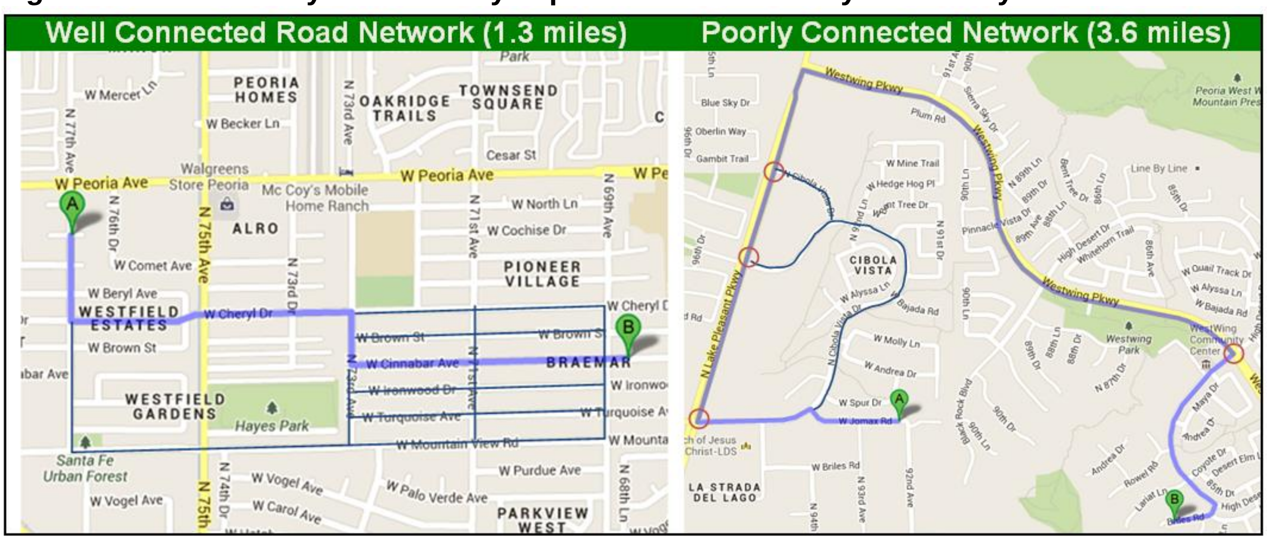
Multi-modal, Accessibility-Based Analysis

Conventional evaluation tends to evaluate transport system performance based on *mobility* (physical movement), using indicators such as roadway level-of-service, traffic speed and delay. This assumes that the main planning goal is to maximize travel speeds, so faster transport options are better than slower options. However, mobility is seldom an end in itself, the ultimate goal of most travel activity is *accessibility*, which refers to people's overall ability to reach desired services and activities. Several factors affect accessibility (CTS 2010; Litman 2003):

- *Motor vehicle travel conditions*. Vehicle traffic speeds, safety and affordability.
- *Quality of other modes*. The quality (speed, convenience, comfort, affordability and safety) of walking, cycling, public transit, telecommunications and delivery services.
- *Transport network connectivity*. The density of connections between paths, roads and public transit, and therefore the directness of travel between destinations (Figure 2).
- *Geographic proximity*. Land use density and mix, and therefore distances between activities.

Planning decisions often involve tradeoffs between various accessibility factors. For example, expanding roads to increase traffic speeds tends to degrade non-motorized travel conditions (called the *barrier effect*), while walking, cycling and public transit improvements such as additional crosswalks, traffic calming, bike lanes and bus lanes often reduce vehicle traffic speed and sometimes on-street parking supply. Increasing block lengths, reducing intersections, and one-way streets tend to increase traffic speeds but reduce connectivity which increases travel distances. Locations along major highways tends to be convenient for automobile access but difficult to reach by other modes, while central locations tend to be more convenient to access by walking and transit, but have more intense traffic and parking congestion.

Figure 2 **Roadway Connectivity Impacts on Accessibility and Safety**



*Although points **A** and **B** are approximately the same distance apart in both maps, the functional travel distance is nearly three times farther with the poorly-connected, hierarchical road network. Because it forces most trips onto major roads a hierarchical network tends to increase total traffic congestion and accident risk, particularly where vehicles turn on and off major arterials (red circles).*

Table 5 summarizes the degree that conventional transport evaluation considers various accessibility factors, and requirements for more comprehensive evaluation. Conventional evaluation primarily considers motor vehicle travel speeds; other modes, other service quality factors (comfort and affordability), transport network connectivity, and land use accessibility are often ignored or only considered at a regional scale.

Table 5 **Consideration of Accessibility Factors In Transport Planning**

Factor	Consideration in Conventional Evaluation	Required for More Comprehensive Evaluation
Motor vehicle travel conditions – convenience, speed, safety and affordability	Usually considered using indicators such as roadway level-of-service, traffic speeds and congestion delay, parking supply, and crash rates.	Impacts should be considered per capita (per capita vehicle costs and crash casualties) to take into account the amount residents must drive
Quality of other modes – convenience, comfort, safety and affordability of walking, cycling, ridesharing and public transport	Considers transit speed and sometimes affordability, but not comfort. Non-motorized modes are generally ignored.	Multi-modal transport system performance indicators that account for convenience, comfort, safety, affordability and integration
Transport network connectivity – density of connections between paths, roads and modes, and therefore the directness of travel between destinations	Traffic network models consider major regional road and transit networks. Local streets, sidewalks, paths, and connections between modes are often ignored.	Fine-grained analysis of sidewalk, path and road network connectivity, and consideration of the connections between modes, such as the ease of walking and cycling to public transit
Geographic proximity – land use density and mix, and therefore the distances between activities	Often ignored. Some integrated models consider some land use factors.	Fine-grained analysis of how land use factors affect accessibility by various modes.

Conventional planning evaluates transport system performance based primarily on motor vehicle travel speed and operating costs. New methods are needed for more comprehensive accessibility evaluation.

Effects on Planning Decisions

Often-overlooked accessibility factors are often significant. Various studies using various analysis methods indicate that the quality of transport options, roadway connectivity and land use accessibility can affect overall accessibility as much as vehicle traffic speeds. For example, research by Ewing and Cervero (2010) and Handy, Tal and Boarnet (2010) conclude that increasing urban intersection density by 10% reduces vehicle travel an average of 1.2%. Levine, et al. (2012) found that development density has about ten times as much influence on the number of destinations that can be reached in a given time period as the same percentage increase in traffic speeds. Kuzmyak (2012) found that central neighborhood residents make substantially shorter trips, drive significantly fewer daily miles and experience less congestion delays than suburban residents due to their improved travel options, more connected streets and greater proximity to destinations. According to the *Urban Mobility Report*, commuters in dense urban regions such as Washington DC and Los Angeles bear congestion costs that average 34 hours of delay and 16.5 gallons of fuel annually, which is much smaller than the additional 104 hours of travel time and 183 gallons of fuel consumed annually by residents in sprawled, automobile-dependent regions such as Jacksonville, Nashville and Houston (Litman 2012). These studies illustrate the importance of multi-modal, accessibility-based analysis for comprehensive transport system performance evaluation.

Congestion Costing Methods

Conventional transport planning places considerable weight on congestion costs: Congestion is often assumed to be the primary transportation problem and congestion reductions are often the primary benefit of urban transport system improvements. As a result, how congestion costs are calculated can significantly affect urban transport planning decisions. Table 6 summarizes economists' recommendations for key congestion costing factors.

Table 6 **Congestion Costing Factors** (TC 2006; Wallis and Lupton 2013)

Evaluation Factor	Economists' Recommended Practices
Baseline speeds – the traffic speed below which congestion costs are calculated.	Capacity maximizing traffic speeds, which is typically about level-of-service C.
Travel time unit costs – the dollars per hour or cents per minute used to calculate delay costs.	30-50% of average wages for personal travel time
Speed-emission curve – changes in fuel consumption and emissions caused by traffic speed changes.	Use a U-shaped curve which recognizes that emissions minimize at moderate (40-50 mph) speeds.
Generated traffic impacts – the increase in vehicle travel that results if congested roadways are expanded, and resulting incremental external costs.	Incorporate generated and induce travel in modeling, and account for incremental external costs including downstream congestion, crashes and pollution.

Various factors affect how congestion costs are calculated.

Conventional economic evaluation often uses congestion costing methods that do not reflect recommended practices; they use freeflow (i.e., level-of-service A) baseline speeds, upper-bound travel time unit costs, and constantly-declining speed emission curves (they assume that increase in traffic speeds reduces fuel consumption and emissions), and they ignore generated traffic impacts (Litman 2013). This exaggerates congestion costs relative to other impacts and the benefits of highway capacity expansion compared with other transport improvement options.

Effects on Planning Decisions

Inaccurate congestion costing can significantly skew planning decisions, particularly because urban transport planning often involves tradeoffs between traffic speed and other objectives such as safety, affordability and improved mobility for non-drivers. For example, exaggerating congestion costs can result in congestion reduction strategies that increase accidents and reduce non-drivers' accessibility, and exaggerating roadway expansion congestion reduction benefits favors urban highway investments over public transit service improvements. Such decisions increase automobile-dependency and reduce transport system diversity.

Needed for More Comprehensive Evaluation

Accurate congestion costing should reflect the practices recommended by economists including optimal baseline speeds, reasonable travel time unit costs, U-shaped speed-emission curves, and consideration of roadway expansion generated traffic impacts (Litman 2013; TC 2006; Wallis and Lupton 2013).

Generated and Induced Travel Impacts

Generated traffic refers to the additional vehicle travel that occurs when a roadway is improved, such as if a congested urban highway is expanded. *Induced travel* reflects the portion of generated traffic that represents net increases in vehicle travel, ignoring route and time shifts. Generated traffic and induced travel have three types of impacts that should be considered in transport economic evaluation (Litman 2001; Noland and Hanson 2013):

1. It reduces congestion reduction benefits.
2. It increases external costs such as downstream congestion, parking subsidies, accidents, energy consumption, pollution emissions and sprawl.
3. It provide additional user benefits (consumer surplus), which tends to be modest since it consists of marginal value vehicle travel that users most willingly forego if congestion delays increase.

Conventional transportation evaluation models incorporate some, but not all, generated traffic and induced travel effects. For example, most traffic models account for shifts in travel route, mode and destinations, but not changes in trips frequency or changes in future land use development (highway expansions tend to encourage more urban fringe, sprawled development, while public transit improvements tend to encourage more central, compact development). Few traffic models accurately predict induced vehicle travel or account for their incremental costs such as changes in downstream congestion, parking costs, vehicle ownership costs, accidents, and pollution emissions that result from induced vehicle travel. Also, few evaluation models explicitly account for changes to users' consumer surplus from changes in their vehicle travel.

Effects on Planning Decisions

Ignoring Generated Traffic effects tends to overstate roadway expansion and undervalues improvements to alternative modes and Transportation Demand Management strategies. A roadway expansion project that appears to provide positive economic returns when generated traffic impacts are ignored may turn out to have smaller or negative economic returns when generated traffic is accurately considered. Models that fail to consider generated traffic tend to overvalue roadway capacity expansion benefits by 50% or more (Litman 2001; Williams and Yamashita 1992).

Needed for More Comprehensive Evaluation

Traffic models should predict all impacts from capacity expansion, including shifts in route, mode, time, destination, and land use development patterns, and identify induced travel (net increases in total vehicle travel). Economic evaluation should account for these changes when evaluating congestion reduction benefits (which tend to decline) and external costs (which tend to increase) when generated and induced travel are accurately evaluated.

Social Equity Analysis

Social equity refers to the distribution (also called *incidence*) of impacts, and whether it is considered fair. There are three general categories of transport equity (Litman 2002):

- *Horizontal equity* (also called *fairness* or *egalitarianism*) concerns whether individuals and groups with similar needs and abilities are treated similarly. It implies that costs should be borne by users unless a subsidy is specifically justified (i.e., the "user pays principle").
- *Vertical equity with regard to income* considers the allocation of costs between different income classes, assuming that public policies should favor people who are economically disadvantaged. Policies that provide a proportionally greater benefit to lower-income groups are called *progressive*, while those that make lower-income people relatively worse off are called *regressive*.
- *Vertical equity with regard to mobility need and ability* considers whether a transport system provides adequate service to people who are *mobility disadvantaged*. It justifies universal design and special mobility services for people with disabilities or other mobility constraints.

Various tools can be used to evaluate these impacts (Forkenbrock and Weisbrod 2001). Although equity impacts are often considered at other stages in the planning process, they are seldom quantified and monetized in economic evaluation.

Effects on Planning Decisions

To the degree that it favors faster travel, conventional evaluation tends to favor motorists over pedestrians, cyclists and transit users, and therefore more affluent and able transport system users over physically and economically disadvantaged people. For example, when evaluating a potential roadway expansion, conventional economic analysis monetizes motorists' time and vehicle operating cost savings but not the additional delay and risk to pedestrians and cyclists, and therefore reduction in transport options available to non-drivers.

Needed for More Comprehensive Evaluation

Various techniques exist for evaluating transportation equity, including analysis of the distribution of costs and benefits, and their impacts on physically, economically and socially disadvantaged people (Forkenbrock and Weisbrod 2001; Litman 2002). For example, analysis can quantify how a project or program affects the quality of mobility and accessibility options available to people with disabilities and low incomes. Similarly, techniques exist for quantifying *option value*, the value people are willing to pay to have an option that they do not currently use, such as physically-able people's willingness to pay for wheelchair ramps, and motorists' willingness to pay for public transport services (DfT 2006; Litman 2009).

Planning Integration

A basic planning principle is that individual short-term decisions should support strategic, long-term goals. This type of planning requires analysis of system-wide impacts, rather than analyzing impacts individually. For example, public transit improvements tend to have greater impacts on travel activity, and therefore provide more benefits and higher economic returns, if implemented with local pedestrian and cycling improvements, supportive land use policies that encourage more compact and mixed development around stops and stations, more efficient parking management, and commute trip reduction programs. Conversely, a highway expansion project may provide less benefit than predicted if it contradicts strategic development objectives by stimulating sprawled land use patterns.

There is considerable variation in the degree that transport economic evaluation reflects system efficiency. Most urban regions have traffic models that evaluate regional roadway system efficiency, but there are often significant gaps in their ability to evaluate other modes, sectors or scales. For example, few regional transport models can provide information on how changes in pedestrian and cycling conditions affect public transit travel and traffic congestion, or how changes in parking policies will affect future mode share and development patterns. This can result in planning decisions at cross-purposes, for example, regional transportation agencies may want to encourage transit-oriented development while local jurisdictions that do little to improve walking and cycling conditions, and impose generous parking requirements on development.

Effects on Planning Decisions

Although the effects vary widely and are difficult to quantify, more integrated evaluation, more accurate evaluation of indirect, long-term and synergistic effects can significantly affect planning decisions (Johnston 2008).

Needed for More Comprehensive Evaluation

Various modelling improvement programs are developing guidance and practical tools for more comprehensive and integrated transport economic evaluation, including more modes (walking, cycling and public transit, in addition to automobile travel), more scales (local as well as regional) and more impacts (Hough and Black 2012; ICE 2006; Johnston 2008; Rodier and Spiller 2012).

Economic Efficiency

Economic efficiency refers to the overall benefits provided by goods and services. Transport economic efficiency analysis recognizes variations in the value of travel to users and society. For example, a vehicle transporting an injured person to a hospital generally has more value than the same vehicle traveling on the same road with a less urgent mission. Freight and other service and commercial vehicles tend to have relatively high value. High occupancy (rideshare and public transit) vehicles are also more space efficient (they carry more passengers per lane) than most cars. As a result, economic efficiency justifies policies that favor higher value trips and more efficient modes over lower value trips and less efficient modes. This can be accomplished by regulations that give emergency vehicles priority in traffic, and special lanes for freight and high occupancy vehicles, and by pricing that allows higher value trips and more efficient modes to outbid other traffic for scarce road space.

There is considerable economic literature on the economic efficiency benefits of using regulations and pricing to favor higher value trips and more efficient modes. However, conventional transportation economic evaluation does not generally quantify and monetize these impacts: few transportation models report the increased economic efficiency and consumer surplus that would result from pricing and regulations that prioritize higher-value travel.

Effects on Planning Decisions

Prioritizing travel could significantly increase economic efficiency. For example, efficient road and parking pricing (motorists pay tolls and parking fees that reflect marginal costs or cost recovery) typically reduces affected vehicle travel 10-50%, indicating that a significant portion of vehicle travel, particularly urban vehicle travel, is economically inefficient: its marginal benefits are worth less than its marginal costs, so users would forego that travel if they were required to pay full costs (Nelson/Nygaard 2006). Some of the avoided vehicle travel would shift to other modes, and providing high occupancy vehicle priority also increases their operating efficiency (buses and rideshare vehicles experience less congestion delay, reducing their unit costs), so more efficient transport system management would probably significantly improve transport options (the quality of walking, cycling and public transport). This suggests that applying economic efficiency principles can significantly increase transport system efficiency and provide significant benefits.

Needed for More Comprehensive Evaluation

Transportation economic efficiency evaluation should account for variation in values of vehicle travel, and therefore the potential economic efficiency gains from policies and projects that favor higher value trips and more resource efficient modes. This evaluation would include analysis of full costs (in order to define optimal pricing), demand modeling that estimates how users would respond to efficient prices, and calculations of net changes in consumer surplus and external costs with the implementation of more efficient regulations and pricing.

Consumer Sovereignty (Responding to Consumer Demands)

Consumer sovereignty refers to the degree that markets respond to consumer demands. Consumer welfare increases if transport system users can choose the combination of modes and services that meet their preferences and needs. In a typical community:

- 20-40% of residents cannot or should not drive due to age, disability or low-income.
- 10-30% of trips are short enough to be efficiently made by walking and cycling.
- Some people prefer to walk, bike and use public transit for exercise and enjoyment.

Consumer welfare increases if transport systems serve latent demands. For example, consumer welfare increases if sidewalk and bikepaths improvements allow residents to walk and bike to local destinations, rather than always need to drive or be chauffeured. Similarly, user benefits are inceased if commuters who prefer can walk, bike, rideshare or use public transit rather than always driving. Improving these modes provides direct user benefits (consumer surplus gains) in addition to external savings and benefits such as reduce traffic and parking congestion. User benefits also increase if households that want to are able to live in accessible, multi-modal (walkable and transit-oriented) neighborhoods rather than being forced to locate in automobile-dependent neighborhoods due to inadequate supply.

In various ways, conventional transport evaluation tends to overlook and undervalue demand for walking, cycling and high quality public transport. Travel surveys tend to undercount short trips, children's travel, non-commute travel, recreational travel, and the walking and cycling links of motorized travel. Few travel surveys collect information on latent demand, such as the portion of residents who would like to rely more on walking, cycling and public transit, and how they would respond to specific service improvements such as faster and less crowded public transit. Economic evaluation does not recognize the full costs that result if inadequate options force drivers to chauffeur non-drivers.

Effects on Planning Decisions

Undervaluing demand for alternative modes, and ignoring the consumer welfare benefits of serving this demand can significantly undervalue walking, cycling and public transport improvements. Experience in various communities shows that improving walking, cycling and public transit travel often results in significant increases in the use of these modes, indicating latent demand (C40 Cities 2008; FHWA 2012).

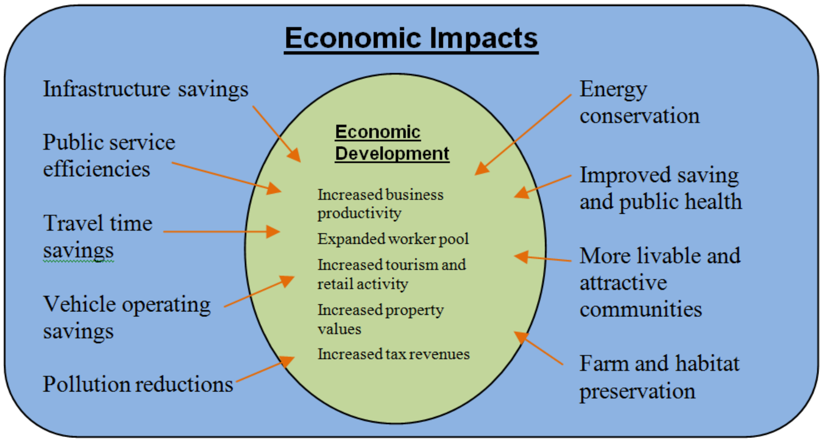
Needed for More Comprehensive Evaluation

Economic evaluation can quantify latent demand for resource efficient modes (walking, cycling and public transport), investigate latent demand for these modes and for more accessible, multi-modal locations, and quantify the benefits to users and society of meeting this demand.

Economic Development Analysis

Economic development refers to progress toward a community's economic goals such as increased productivity, business activity, employment, income, property values and tax revenues (Ellis, Glover and Norboge 2012). Economic development can provide external benefits: residents may benefit from a transport facility or service they do not use if it increases local employment and tax revenue. Transport improvements tend to support economic development if they increase producer (government and business) efficiencies, for example, by reducing road and parking facility costs (and therefore tax and development costs), reducing shipping costs or expanding labor pools, as illustrated in Figure 3.

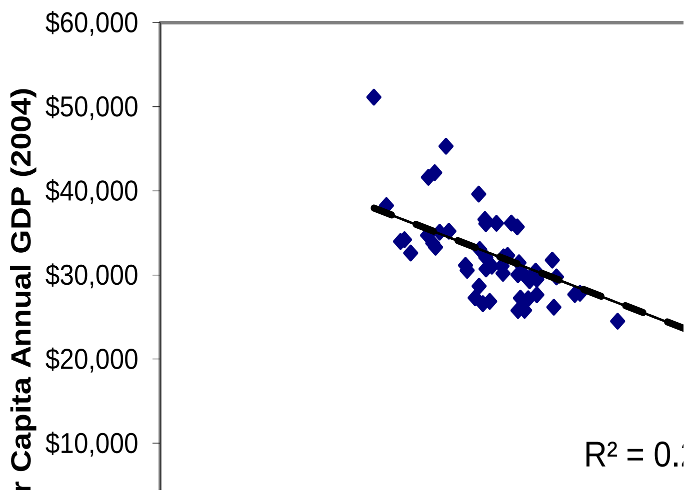
Figure 3 **Economic and Economic Development Impacts**



Economic "impacts" are changes in the supply of scarce resources, including time, money, land, energy, health and ecological productivity. Economic "development" which are changes in economic productivity, employment, property values and tax revenues. Resource efficiencies to producers (businesses and governments) tend to support economic development.

Under certain circumstances, such as when paved highways are first built in a region, roadway expansion tends to provide significant economic development benefits, but theoretical and empirical evidence indicate that as roadway systems mature marginal economic development benefits decline (Mamuneas and Nadiri 2006), and although internationally, vehicle travel is positively associated with productivity, since vehicle travel tends to increase with income, within higher-income countries, high levels of motor vehicle travel tend to reduce productivity (Kooshian and Winkelman 2011), as illustrated in Figure 4.

Figure 4 **Per Capita GDP and VMT For U.S. States** (Litman 2010)



Per capita economic productivity increases as vehicle travel declines. (Each dot is a U.S. state.)

Conventional evaluation often exaggerates transport project economic development benefits by treating economic transfers (subsidies from other sectors or jurisdictions) as net benefits, assuming that personal cost savings increase productivity, and by ignoring incremental external costs of increased vehicle travel (Cambridge Systematics 2012; Crompton 2006). This is an important issue because policies and projects that stimulate automobile travel, such as roadway expansions, parking subsidies and low fuel prices, are often justified based on claims that increased vehicle travel supports regional economic development, employment and tax revenues.

Effects on Planning Decisions

Economic development can provide dispersed benefits and so is often considered worthy of public support. As a result, transport projects are often justified with claims that they support economic development. Exaggerating transport projects' economic development benefits can result in excess and inefficient investments, particularly if they induce additional vehicle travel that significantly increases indirect and external costs.

Needed for More Comprehensive Evaluation

Transportation economic development analysis should reflect best practices: it should not consider economic transfers as net benefits, it should not expect productivity gains from personal travel cost savings, and it should recognize the incremental economic costs of increased vehicle travel (additional road and parking costs, accident and pollution damages, economic externalities from fuel importation, and sprawl-related costs). Integrated models such as *TranSight* and *TREDIS* are now available that, if properly applied, provide more accurate economic development impact analysis of transportation projects.

Summary

Table 7 summarizes the degree that conventional transport economic evaluation considers these eight factors. This analysis indicates that significant changes are needed to make transport economic evaluation truly comprehensive and multi-modal.

Table 7 **Analysis Scope**

Factor	Conventional Transport Evaluation	Required for Comprehensive Evaluation
Scope of impacts and objectives considered	Often considers a limited set of impacts and objectives, primarily related to automobile travel such as traffic speeds, vehicle operating costs, crash and emission rates.	Consider all significant impacts and planning objectives.
Accessibility analysis	Evaluates transport system performance based primarily on vehicle traffic speeds. The quality of other modes, network connectivity and geographic proximity often receive little consideration.	Considers all accessibility factors including motor vehicle traffic speeds, the quality of alternative modes, transport network connectivity, and geographic proximity.
Congestion costing	Often uses costing methods that exaggerate congestion costs and highway expansion benefits	Apply best practices when evaluating congestion costs
Generated traffic impacts	Most transport models consider some but not all generated traffic impacts; land use development impacts and the incremental costs of induced vehicle travel are often overlooked or undervalued.	Consider the incremental benefits and costs of induced vehicle travel.
Social equity analysis	Equity impacts are often considered at some point in the planning process but seldom quantified.	Define and measure equity impacts as part of economic evaluation.
Strategic planning	Evaluation is often uncoordinated between different sectors and jurisdictions.	Provide more integrated analysis.
Economic efficiency	Not generally quantified, so the efficiency benefits of favoring higher value trips and more efficient modes are not evaluated.	Account for the economic efficiency gains that could result from increased economic efficiency.
Consumer sovereignty	Seldom quantifies latent travel demands and the benefits to users and society of accommodating latent demand for resource efficient modes.	Better analysis of travel demands, and the potential benefits of serving latent demand for walking, cycling and public transport.
Economic development	Often exaggerates the economic development benefits of increased mobility.	Critically evaluate claims of economic development benefits, particularly from roadway expansions.

Compared with conventional practices, significant changes are needed to create truly comprehensive and multi-modal transport economic evaluation.

Examples

This section investigates how the omissions and biases of conventional transport economic evaluation can affect various types of transport planning decisions.

School Transport

Many schools experience local traffic and parking congestion due in part to students driving or being chauffeured. There are two conflicting solutions: expand local roads and add more drop-off parking, or implement local pedestrian and cycling improvements, reduce local road traffic speeds, and implement school transport management programs that encourage walking, cycling and carpooling. Table 8 examines how various evaluation distortions tend to affect this planning decision.

Table 8 **Impacts on School Travel Improvement Analysis**

Evaluation Distortion	Impacts on School Transport Planning
Limited scope of impacts and objectives considered	Favors roadway expansion by failing to monetize the value of household cost savings, improved mobility for non-drivers, and health benefits if children walk and bike instead of being driven to school.
Mobility-oriented evaluation that overlooks impacts on other modes, network connectivity and proximity	Favors roadway expansion by failing to account for their negative impacts on walking and cycling access.
Exaggerated congestion costs and roadway expansion benefits	Favors roadway expansion by exaggerating congestion reduction benefits.
Underestimates generated traffic impacts	Favors roadway expansion by exaggerating congestion reduction benefits and ignoring increases in external costs.
Ignores social equity impacts and objectives	Favors roadway expansion by ignoring the value to society of improving affordable mobility options for non-drivers.
Inadequate planning integration	Favors roadway expansion if a community has strategic objectives to encourage more compact development.
Failure to consider economic efficiency (the benefits of favoring higher value trips and more efficient modes)	Favors expansion of general traffic lanes over strategies that favor walking, cycling and public transit such as bike and bus lanes, and carshare priority parking.
Consumer sovereignty (the benefits of serving latent demand, particularly for resource-efficient modes)	Favors continuing automobile-oriented improvements over improvements to other, less frequently used modes for which there may be latent demand.
Exaggerated economic development benefits of roadway expansion	Sometimes favors roadway expansions by assuming that increased vehicle travel supports economic development.

Conventional transport economic evaluation is biased in various ways that tend to favor roadway expansions and additional parking to the detriment of other modes.

In recent years many communities have implemented school transport management (often called *safe routes to schools*) programs which reflect an appreciation of the benefits of improving walking and cycling. However, this occurs despite rather than supported by conventional economic evaluation which, as this analysis indicates, tends to undervalue active transport.

Urban Congestion Reduction

Urban traffic congestion is a significant problem and most urban regions are investing significant resources to improve mobility, including roadway expansion, public transit improvements, and various transportation demand management programs. Table 9 examines how economic evaluation biases are likely to affect the evaluation of potential congestion reduction strategies.

Table 9 Urban Congestion Reduction Analysis

Evaluation Distortion	Impacts on Congestion Mitigation Planning
Limited scope of impacts and objectives considered	Favors roadway expansion by failing to monetize many benefits of alternative modes and TDM, such as parking cost savings, household savings and improved mobility for non-drivers.
Mobility-oriented evaluation that overlooks impacts on other modes, network connectivity and proximity	Favors roadway expansion by failing to account for the reductions in walking and cycling access, reduced roadway connectivity, and increased sprawl that typically results from higher design speeds.
Exaggerated congestion costs and roadway expansion benefits	Favors roadway expansion by exaggerating congestion reduction benefits.
Underestimates generated traffic impacts	Favors roadway expansion by exaggerating their congestion reduction benefits and ignoring increases in external costs.
Ignores social equity impacts and objectives	Favors roadway expansion by ignoring the value to society of improving affordable mobility options for non-drivers.
Inadequate planning integration	Favors roadway expansion by overlooking the additional congestion reductions and other benefits of integrated programs involving transit improvements, TDM and smart growth policies.
Failure to consider economic efficiency (the benefits of favoring higher value trips and more efficient modes)	Favors expansion of general traffic lanes over strategies that favor higher value trips and more efficient modes such as bike, HOV and bus lanes, and efficient road pricing.
Consumer sovereignty (the benefits of serving latent demand, particularly for resource-efficient modes)	Favors roadway expansion over improvements to other, less frequently used modes for which there may be latent demand, such as cycling, vanpooling and high quality public transit.
Exaggerated economic development benefits of roadway expansion	Favors roadway expansions by assuming that increased vehicle travel supports economic development.

Conventional transport economic evaluation is biased in various ways that tend to favor roadway expansion over other congestion reduction strategies such as bike, HOV and bus lanes, pricing reforms and commute trip reduction programs.

This analysis indicates that conventional transport economic evaluation is biased in favor of highway expansion over other potential congestion reduction strategies because it ignores their co-benefits, such as parking cost savings, vehicle ownership cost savings and safety benefits, exaggerates roadway expansion congestion reduction benefits, ignores the economic efficiency benefits of efficient pricing which favors higher value trips, ignores the social equity and consumer surplus benefits of improving mobility options for non-drivers, and the additional potential impacts and benefits of integrated programs.

Bus Rapid Transit Project

Many communities are now considering implementing various types of Bus Rapid Transit (BRT) projects which involve frequent bus services with features such as bus only-lanes and intersection priority, integrated pre-paid fares (which minimizes boarding delays), attractive stations and aggressive marketing. This tends to improve operating efficiencies (more passenger-miles per bus operating hour), improve transit service quality and increase ridership, but often has significant implementation costs and may require eliminating general traffic or parking lanes. Table 10 examines how evaluation biases are likely to affect BRT benefit evaluation.

Table 10 **Bus Rapid Transit Benefit Analysis**

Evaluation Distortion	Impacts on BRT Evaluation
Limited scope of impacts and objectives considered	Undervalues BRT by failing to monetize many benefits of alternative modes and TDM, such as parking cost savings, household savings and improved mobility for non-drivers.
Mobility-oriented evaluation that overlooks impacts on other modes, network connectivity and proximity	Often undervalues BRT by failing to account for the congestion avoided when travelers shift from driving to other modes.
Exaggerated congestion costs and roadway expansion benefits	Favors roadway expansion over BRT by exaggerating roadway congestion reduction benefits.
Underestimates generated traffic impacts	Favors roadway expansion over BRT by exaggerating roadway congestion reduction benefits.
Ignores social equity impacts and objectives	Undervalues BRT by ignoring the value to society of improving affordable mobility options for non-drivers.
Inadequate planning integration	May undervalue BRT by failing to account the additional ridership and benefits that could result from integrated BRT, TDM and smart growth policies, and by overlooking the way it supports other strategic objectives such as compact development.
Failure to consider economic efficiency (the benefits of favoring higher value trips and more efficient modes)	May undervalue BRT by failing to account for the economic efficiency gains from urban traffic management that favors higher value trips and more efficient modes.
Consumer sovereignty (the benefits of serving latent demand, particularly for resource-efficient modes)	May undervalue BRT by failing to account for the consumer surplus gains provided by serving latent demand for high quality public transport.
Exaggerated economic development benefits of roadway expansion	May undervalue BRT if evaluation models fail to recognize the full economic development benefits of increased economic opportunity for non-drivers, agglomeration benefits of more compact development, and increased regional productivity from reduced household expenditures on vehicles and fuel.

Conventional transport economic evaluation fails to recognize many benefits of high quality public transport.

Conventional evaluation tends to undervalue BRT investments because it fails to recognize many benefits of high quality public transport including improved user speed and comfort, parking and vehicle ownership cost savings, social equity and consumer surplus benefits of improving mobility for non-drivers, and benefits from more compact development.

Conclusions

The scope of impacts, objectives and options considered in economic evaluation can significantly affect transport planning decisions: a policy or project may appear beneficial and fair evaluated one way but inefficient and unfair if evaluated another. It is important that people who use analysis result understand their weaknesses. This study identifies significant omissions and biases in conventional economic evaluation:

- It fails to quantify and monetize significant impacts including parking costs, vehicle ownership costs, disadvantaged people's accessibility, and public fitness.
- It focuses on automobile travel and gives little consideration to impacts on accessibility factors such as the quality other modes, transport network connectivity, or geographic proximity.
- It exaggerates congestion costs and roadway expansion benefits.
- It fails to incorporate social equity and strategic planning objectives.
- It does not account for the economic efficiency gains of favoring higher value trips and more efficient modes, or the consumer surplus benefits of serving latent demands.
- It tends to exaggerate roadway expansion economic development benefits.

These biases and omissions tend to favor of mobility over accessibility and automobile travel over other modes, resulting in economically excessive roadway expansion, underinvestment in walking, cycling and public transit, and reduced support for pricing reforms and smart growth policies. This harms consumers directly, by reducing their transport options and increasing their costs, reduces economic efficiency and increases various external costs. Conventional evaluation practices were originally developed during the mid-twentieth century, during the period of rapid motor vehicle travel growth, to answer relatively simple questions such as whether a highway project's costs would be repaid by travel time and vehicle operating cost savings. These practices are inadequate for evaluating more complex decisions that affect the range of transport options available in a community, or which have significant indirect and external impacts, as is common with urban transport planning and strategic policy and planning decisions.

To be fair, the excluded impacts and factors are often considered at other stages in a planning process, such as during political negotiations and public engagement, and other factors often affect planning decisions such as funding formulas. Public officials often support walking, cycling and public transport more than is justified by conventional economic evaluation – they realize intuitively that these modes play important roles in an efficient and equitable transport system that are not quantified in economic evaluation. However, this occurs *despite* rather than supported by the evaluation process. More comprehensive and multi-modal evaluation can result in more integrated and consistent planning.

The omissions and biases identified in this report have been described previously, some in the regional or transport planning literature, some in the economics literature, and some by groups interested in specific issues such as social equity analysis or public health. However, to my knowledge this is the first study which attempts to provide a comprehensive critique that bridges these various perspectives. This study should be of interest to anybody involved in transport evaluation or who uses evaluation results.

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