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Evaluating Active Transport Benefits and Costs

Guide to Valuing Walking and Cycling Improvements and Encouragement Programs

1 November 2013

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Abstract
This report describes methods for evaluating the benefits and costs of *active transport* (walking, cycling, and their variants, also called *non-motorized* and *human-powered travel*). It describes various types of benefits and costs and methods for measuring them. These include direct benefits to users from improved active transport conditions, and various benefits to society from increased walking and cycling activity, reduced motor vehicle travel, and more compact and multi-modal community development. It discusses active transport demands and ways to increase walking and cycling activity. This analysis indicates that many active transport benefits tend to be overlooked or undervalued in conventional transport economic evaluation.

Previously called "Evaluating Non-Motorized Transportation Benefits and Costs"
This report updates and expands on,
"Bicycling and Transportation Demand Management,"
Transportation Research Record 1441, Transportation Research Board, 1994, pp. 134-140.

Contents

Executive Summary

Active transport (also called *non-motorized transport* or *NMT*, and *human powered transport*) refers to walking, cycling, and variants such as wheelchair, scooter and handcart use. Active transport plays important and unique roles in an efficient and equitable transportation system. It provides basic mobility, affordable transport, access to motorized modes, physical fitness, and enjoyment. Improving active conditions can benefit users directly, plus various indirect benefits, so even people who do not use a particular sidewalk, crosswalk, path or bikerack often benefit from their existence.

This report describes the impacts (benefits and costs) of policies and projects that improve active transport conditions and increase active mode use. It discusses factors that affect these impacts, describes methods for quantifying and *monetizing* (measuring in monetary units) them. Table ES-1 lists various categories of active transport benefits and costs. Conventional transport economic evaluation tends to overlook and undervalue active benefits and so tends to undervalue walking and cycling improvements.

Table ES-1 **Active Transportation Benefits and Costs**

	Improved NMT Conditions	Increased NMT Transport Activity	Reduced Automobile Travel	More Compact Communities
Potential Benefits	• Improved user convenience and comfort • Improved accessibility for non-drivers, which supports equity objectives • Option value • Supports related industries (e.g., retail and tourism) • Increased security	• User enjoyment • Improved public fitness and health • Increased community cohesion (positive interactions among neighbors due to more people walking on local streets) which tends to increase local security	• Reduced traffic congestion • Road and parking facility cost savings • Consumer savings • Reduced chauffeuring burdens • Increased traffic safety • Energy conservation • Pollution reductions • Economic development	• Improved accessibility, particularly for non-drivers • Transport cost savings • Reduced sprawl costs • Openspace preservation • More livable communities • Higher property values • Improved security
Potential Costs	• Facility costs • Lower traffic speeds	• Equipment costs (shoes, bikes, etc.) • Increased crash risk	• Slower travel	• Increases in some development costs

Active transport can have various benefits and costs.

Some of these impacts are relatively easy to measure. Economists often monetize facility costs, traffic congestion, vehicle operation, crash damage, and pollution costs. Methods also exist for evaluating health impacts, social equity, affordability and option value (the value of maintaining a currently-unused option) benefits, user enjoyment, and additional environmental benefits such as habitat preservation. This guide describes these methods and how they can be used for more comprehensive evaluation of active impacts.

This report should be of interest to transportation policy analysts, planners, economists and engineers, plus active transport advocates.

Introduction

Active transport (also called *non-motorized transport*, *NMT* and *human powered transport*) refers to walking, cycling, and variants such as wheelchair, scooter and handcart use. It includes both utilitarian and recreational travel activity, plus stationary uses of pedestrian environments such as standing on sidewalks and sitting at bus stops. In this report, *pedestrian*, *walker*, *cyclist*, and *non-driver* refer to active mode users, and *motorist* and *driver* refer to automobile users, although most people fall into multiple categories.

These modes play important and unique roles in an efficient and equitable transport system:

- Typically 10-20% of local trips are entirely by active modes, and most trips involve active links, for example, to access public transit, and from parked cars to destinations.
- Improving active transport can achieve transport planning objectives including reduced traffic and parking congestion, energy consumption and pollution emissions, and help create more compact "smart growth" development.
- Walking and cycling provide affordable, basic transport. Physically, economically and socially disadvantaged people often rely on walking and cycling, so improving active transport can help achieve social equity and economic opportunity objectives.
- Active transport is the most common form of physical exercise. Increasing walking and cycling is often the most practical way to improve public fitness and health.
- Pedestrian environments (sidewalks, paths and hallways) are a major portion of the public realm. Many beneficial activities (socializing, waiting, shopping and eating) occur in pedestrian environments. Residential and commercial districts and resort communities depend on good walkable environments to attract customers.
- Walking and cycling are popular recreational activities. Improving walking and cycling conditions provides enjoyment and health benefits to users, and supports related industries, including retail, recreation and tourism.

Many planning decisions affect walking and cycling conditions, and therefore the amount of active travel that occurs in a community. To the degree that a planning process undervalues active transport it will underinvest in these modes, reducing overall transport system diversity and efficiency.

Conventional transportation economic evaluation tends to overlook and undervalue many active transportation benefits. This report describes methods for more comprehensive evaluation of these impacts. Because active travel is diverse, some analysis in this report only applies to certain conditions, modes or trips. For example, some analysis applies primarily to walking, others primarily to cycling, some to certain users (such as people with disabilities), and some to certain conditions (such as active access to public transit). Users should use judgment to determine what is appropriate for their analysis.

Active Transport And Transport Diversity

Many communities are, to various degrees, *automobile dependent*, meaning that their transport systems and land use patterns favor automobile access and provide relatively poor access by other modes. The alternative is generally not a *car-free* community where driving is forbidden, rather, it is a community with a *diverse* (or *multi-modal*) transport system, which provides various accessibility options, including good walking, cycling, public transit, automobile, taxi, telework and delivery services.

Active modes play important roles in a diverse transport system. Where walking and cycling conditions are good, typically 10-20% of local trips are by these modes. Walking and cycling provide access to public transit; often the best way to improve and encourage public transit travel is to improve local walking and cycling conditions. Walking provides connections between parked vehicles and destinations, so pedestrian improvements can help reduce parking problems. Physically, economically and socially disadvantaged people tend to rely significantly on active modes, so they provide equity value. If walking and cycling conditions are inadequate, non-drivers must rely either on taxi travel or chauffeuring (special trips made to transport a passenger), which is costly and inefficient, particularly because such trips often involve empty backhauls, so each passenger-mile generates two vehicle-miles of travel.

Because transport demands are diverse (different people, areas and trips have differing travel needs and abilities), increasing transport system diversity tends increase efficiency and equity by allowing each mode to be used for what it does best. For example, it is inefficient if physically able people who enjoy walking and cycling are forced to drive for short trips due to poor active travel conditions. Similarly, it is inefficient if people who would like to use public transit cannot due to poor walking and cycling access to bus stops or train stations.

A transportation system is an integrated network; its efficiency depends on the quality of modes and the links between them. For example, a person’s ability to commute without a car may depend not only on the quality of transit services, but also on the perceived safety of bus stops and train stations, the quality of walking and cycling conditions, the ease of obtaining information about these travel options, the ease of paying a fare, and the social acceptability of commuting by transit. Because of these relationships it can be difficult to value a single system change; for example, in one location, improving walking and cycling access to a bus stop may significantly increase ridership, but in another location have much smaller impacts.

Active Transport Demand and Modeling

Transport demand refers to the amount and type of travel people would choose in specific conditions. Various demographics, economic, and land use factors can affect active travel demands (Table 1).

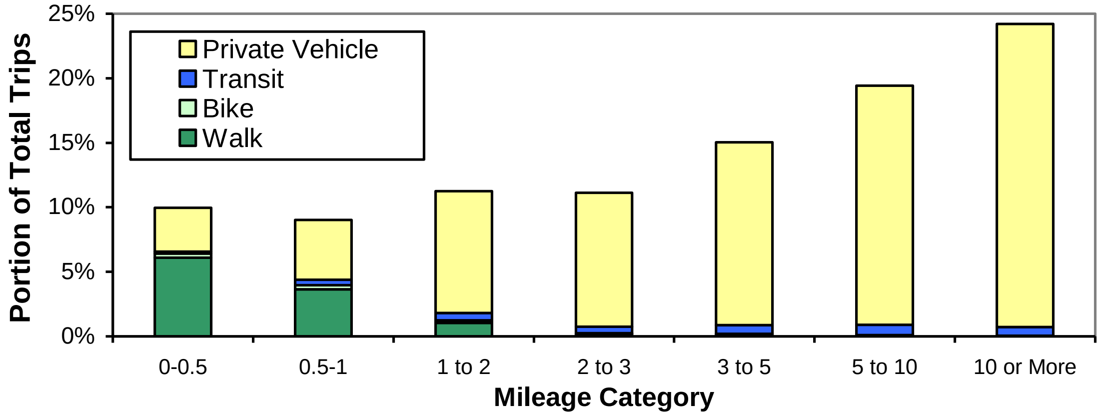
Table 1 **Factors Affecting Walking and Cycling Travel Demand** (Based on Dill and Gliebe 2008; Pratt, et al. 2012)

Factors	Impacts on Active Travel
Age	Young people tend to have high rates of walking and cycling. Some older people have high rates of walking for transportation and exercise.
Physical ability	Some people with impairments rely on walking and cycling, and may require facilities with suitable design features, such as ramps for walkers and wheelchairs.
Income and education	Many lower-income people tend to rely on active modes for transportation. Bicycle commuting is popular among higher income professionals.
Dogs	Daily walking trips tend to be higher in households that own dogs.
Vehicles and drivers licenses	People who do not have a car or driver's license tend to rely on walking and cycling for transportation.
Travel costs	Walking and cycling tend to increase with the cost of driving (parking fees, fuel taxes, road tolls, etc.)
Facilities	Walking and cycling activity tend to increase where there are good facilities (sidewalks, crosswalks, paths, bikeracks, etc.)
Roadway conditions	Walking and cycling tend to increase in areas with narrower roads and lower vehicle traffic speeds.
Trip length	Walking and cycling are most common for shorter (less than 2-mile) trips.
Land use	Walking and cycling tend to increase in areas with compact and mixed development where more common destinations are within walking distances.
Promotion	Walking and cycling activity may be increased with campaigns that promote these activities for health and environmental improvement sake.
Public support	Cycling rates tend to increase where communities consider it socially acceptable.

Many factors can affect active travel demand.

Various methods are used to measure walking and cycling activity, including travel surveys, and instruments that count pedestrians and cyclists (Charlier Associates, Krizek and Forsyth 2012; FHWA 2012b; Ryan and Lindsey 2013). Conventional statistics tend to underreport active travel activity because most travel surveys undercount shorter trips (those within a *traffic analysis zone*), off-peak trips, non-work trips, travel by children, and recreational travel (ABW 2010; Stopher and Greaves 2007). Many surveys ignore active links of motor vehicle trips, for example, a *bike-transit-walk* trip is often classified simply as a transit trip, and a motorist who walks several blocks from a parked car to a destination is classified as an auto user. More comprehensive surveys indicate that active travel is three to six times more common than conventional surveys indicate (Rietveld 2000; Forsyth, Krizek and Agrawal 2010; Pike 2011), so if statistics indicate that only 5% of trips are active, the actual amount is probably 10-30% (Litman 2010).

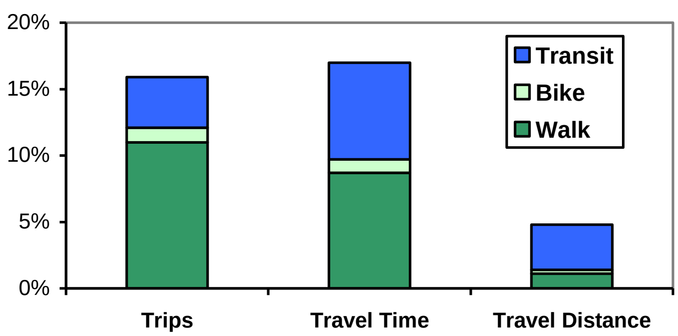
Figure 1 **Mode Share By Mileage Category** (Litman 2010)



This figure illustrates the share of total trips by mode and trip distance category.

According to the 2009 U.S. *National Household Travel Survey*, 10.9% of personal trips are by walking and 1.0% by cycling (Kuzmyak and Dill 2012). Figure 1 shows the mode shares of various length trips. For the 27% of trips less than a mile, 31% are active. About half of walking and cycling trips are purely recreational, and only about 5% are for commuting, so for each active *commute* trip there are about nine other utilitarian active trips, and about ten recreational trips (Gallup 2008). Although active modes serve a small portion of total travel *distance*, they represent a much larger portion of share of *travel time* and *trips*. For example, walking represents only about one percent of total mileage but more than ten percent of trips and travel time, as shown in Figure 2.

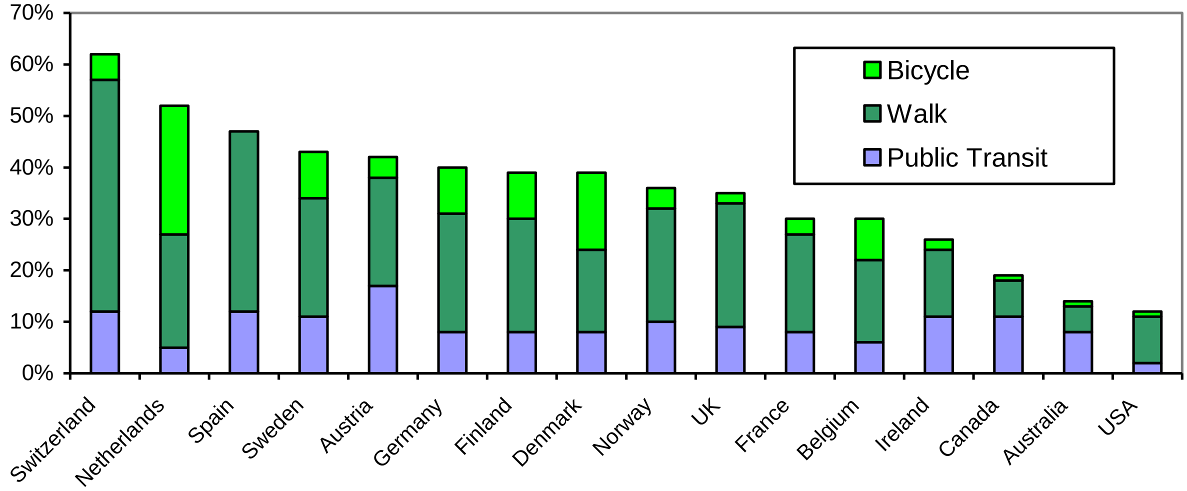
Figure 2 **Mode Share By Distance, Time and Trips** (Litman 2010)



Active modes serve a small portion of travel distance but a larger share of trips and travel time.

Transport modeling refers to methods used to predict how travel activity is affected by specific transport system changes (Krizek, et al. 2006; Pratt, et al. 2012). Conventional travel models can be improved to better incorporate active travel (“Model Improvements,” VTPI 2009), and specialized models can be used to predict how various transport system and land use changes would affect walking and cycling activity (Barnes and Krizek 2005; McDonald, et al. 2007; Molino, et al. 2012). The *TDM Effectiveness Evaluation Model* (TEEM) evaluates the travel impacts and economic benefits of specific pedestrian and bicycle improvements (Loudon, Roberts and Kavage 2007).

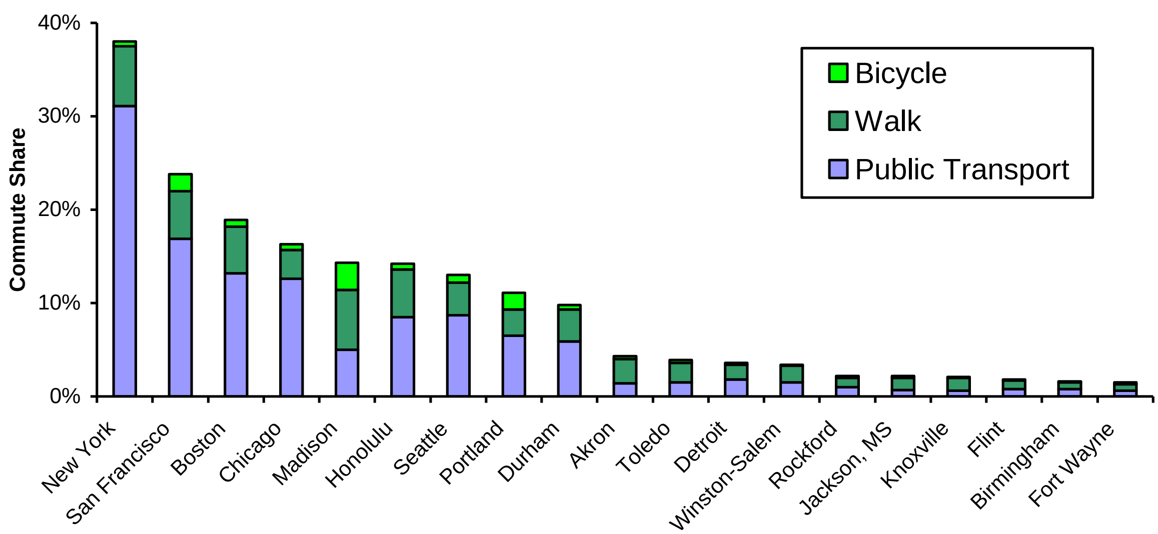
Figure 3 **Mode Share By Country** (Bassett, et al. 2011)



Active travel varies significantly between wealthy countries.

Active transport activity varies widely between different countries and cities, as illustrated in figures 3 and 4. These differences reflect policy and planning factors more than geography or climate. For example, Scandinavian countries, Switzerland, and the Netherlands have cold, wet climates, and San Francisco, Boston, and Seattle are cold, wet and hilly, but all have relatively high active mode share due to supportive transport and land use policies and community attitudes (ABW 2010). Public transit and active travel tend to complement each other, so communities with high transit use also tend to have high rates of walking and cycling (Bassett, et al. 2010).

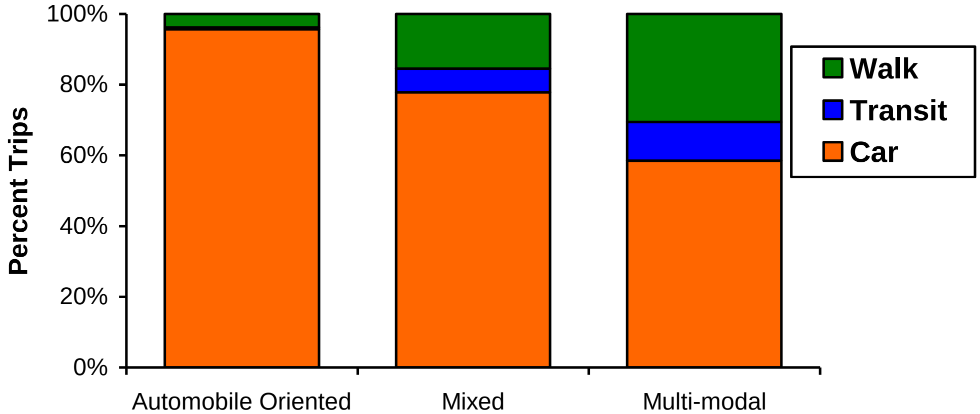
Figure 4 **U.S. Urban Region Commute Mode Share** (U.S. Census 2007)



This figure shows the ten U.S. cities with highest and lowest alternative mode commute share.

Large variations also occur between neighborhoods (Frank, et al. 2010; Litman 2008). Multi-modal neighborhoods often have ten times as much walking and cycling activity as automobile-oriented neighborhoods, as illustrated in Figure 5. Although this partly reflects self-selection (non-drivers tend to choose to live in more multi-modal communities), people who move from automobile-oriented to multi-modal communities often increase their active travel (Cao, Handy and Mokhtarian 2006; Cervero 2007).

Figure 5 **Portland Neighborhood Mode Share** (Lawton 2001)



As an area becomes more urbanized the portion of trips made by transit and walking increases.

In most communities, 20-40% of the population cannot or should not drive due to disabilities, low incomes, or age. In addition, many trips, such as short errands, are most efficiently made by active modes. There is evidence of significant latent demand for active travel; many people want to walk and bicycle more than they currently do but face obstacles (ABW 2010; STPP 2003). Active transport facility improvements often lead to more walking and cycling activity (FHWA 2012; Litman 2009b; Living Streets 2011). Similarly, there appears to be significant latent demand for housing in walkable communities (Leinberger 2012). Current demographic and economic trends (aging population, rising fuel prices, urbanization, growing traffic congestion, and increased health and environmental concerns) are increasing demand for active transport and the potential benefits from accommodating this demand (Litman 2006).

For some evaluations it is important to know vehicle travel substitution rates: the amount that motor vehicle travel declines. In a detailed study of five U.S. communities with active transport improvements Krizek, et al. (2007) found that 30% to 40% of walk and bike commute trips, and about 95% of active mode trips to other destinations, would have been made by driving. The researchers estimate that in these five communities the NMT improvements reduced approximately 0.25 to 0.75 mile of daily driving per adult, 1-4% of total automobile travel. The Australian *TravelSmart* program, which uses various incentives to encourage residents to use alternative modes typically reduces automobile trips 5% to 14%, about half resulting from shifts to active travel (TravelSmart 2005).

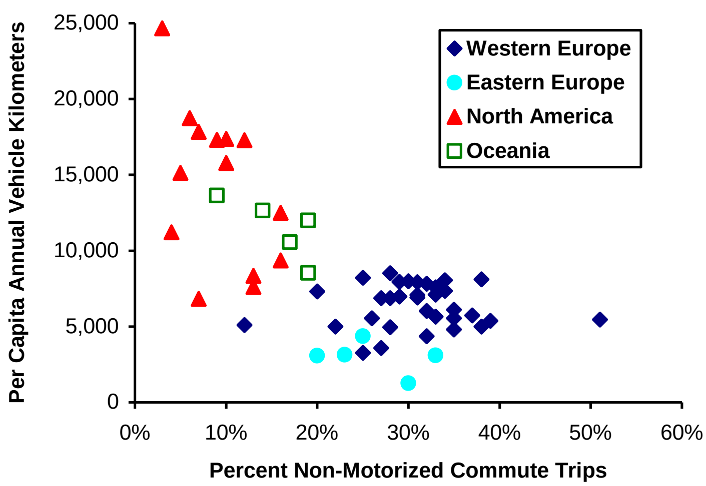
Active Leverage Effects (Cairns et al. 2004; Mackett 2001)
Walking and cycling improvements often leverage additional vehicle travel reductions in these ways:

- *Shorter trips.* A shorter active trip often substitutes for longer motorized trips, such as when people choose a local store rather than driving to more distant shops.
- *Increased public transit.* Walking and cycling improvements can support public transit travel, since most transit trips involve walking and cycling links.
- *Vehicle ownership reductions*. Improving alternative modes can allow some households to reduce their vehicle ownership. Since motor vehicles are costly to own but relatively cheap to use, once households purchase an automobile they tend to use it, including some relatively low-value trips.
- *Land use patterns*. Walking and cycling improvements help create more compact, multi-modal communities by reducing road and parking facility land requirements which reduces travel distances.
- *Social norms.* More walking and cycling can help increase social acceptance of alternative modes.

Not every active improvement has all these effects, but many small changes can help make a community more multi-modal, and therefore reduce total vehicle travel. Conventional planning analysis often ignores these indirect impacts and so underestimates the potential of active improvements to achieve objectives such as reducing congestion, accidents and pollution emissions.

Active travel can leverage additional vehicle travel reductions, as described in the box above. Guo and Gandavarapu (2010) found that installing sidewalks on all streets in a typical North American community would increase walking and cycling by 0.097 average daily miles and reduce automobile travel by 1.142 daily vehicle-miles per capita, about 12 miles of reduced driving for each mile of increased active travel. International data also indicate that each mile of increased active travel is associated with seven miles of reduced motor vehicle travel, illustrated in Figure 6.

Figure 6 **Active Vs. Motorized Transport** (Kenworthy and Laube 2000)



International data indicate that motor vehicle travel tends to decline as active travel increases.

Evaluating Active Travel Conditions

Below are examples of performance indicators that can be used to evaluate the quality of walking and cycling conditions ("Performance Evaluation" VTPI 2009):

- *Level-of-Service* (*LOS*, also called *Service Quality*) rates performance from *A* (best) to *F* (worst). Until recently, only motor vehicle LOS ratings were available, but in recent years rating systems have been developed for active modes (TRB 2008; *Walkability Tools Research Website*, www.levelofservice.com). These include:

  1. *Cycling LOS* considers the availability of parallel bicycle paths, the number of unsignalized intersections and driveways, outside through lane and bike lane widths, motor vehicle traffic volumes and speeds, portion of heavy vehicles, the presence of parallel parked cars, grades (hills), and special conflicts such as freeway off-ramps.
  2. *Pedestrian LOS* considers pedestrian facility crowding, the presence of sidewalks and paths, vehicle traffic speeds and volumes, perceived separation between pedestrians and motor vehicle traffic (including barriers such as parked cars and trees), street crossing widths, extra walking required to reach crosswalks, average pedestrian road crossing delay, and special conflicts.

- *WalkScore* (www.walkscore.com) calculates a location's proximity to services such as stores, schools and parks, as an indication of the ease of walking to such destinations. It provides no information on walking condition quality.
- *Neighborhood Bikeability Score* (www.ibpi.usp.pdx.edu/neighborhoods.php) is a rating from 0 (worst) to 100 (best) that indicates the number of destinations (stores, schools, parks, etc.) that can be reached within a 20-minute bike ride, taking into account the quality of cycling infrastructure (McNeil 2010).
- The *Walkability Checklist* and *Bikeability Checklist* developed by the Pedestrian and Bicycle Information Center (www.walkinginfo.org) includes ratings for road and off-road facilities, user behavior, and ways to improve walking and bicycling conditions.
- Surveys that ask users to rate walking conditions, barriers to walking, and the degree that walking and cycling improvements would affect their travel activity (Leather, et al. 2011).
- Before and after studies of walking and cycling improvements that measure changes in active travel activity (Turner, et al. 2011).
- *Acceptable Walking Distance*. The distance people willingly walk is an important factor in some transport and land use planning. It determines the optimal size of a commercial district or urban village, the area served by public transit, and acceptable distances between parking facilities and destinations. The table below indicates pedestrian access LOS.

Table 2 **Level of Service By Walking Trip Distance (in Feet)** (Smith and Butcher 1997)

Walking Environment	LOS A	LOS B	LOS C	LOS D
Climate Controlled	1,000	2,400	3,800	5,200
Outdoor/Covered	500	1,000	1,500	2,000
Outdoor/Uncovered	400	800	1,200	1,600
Through Surface Lot	350	700	1,050	1,400
Inside Parking Facility	300	600	900	1,200

This table rates acceptable walking distance for various conditions.

Active Transport Improvement and Encouragement Strategies

There are many possible ways to improve and encourage active transport (Alta Planning 2005; FHWA 2004; VTPI 2010). Active mode improvement and encouragement programs tend to have synergistic effects (total impacts are greater than the sum of their individual impacts), so it is generally best to implement and evaluate integrated programs. Experts generally recommend that active mode plans include *Four Es*: engineering, encouragement, education and enforcement. Below are examples:

- *Walking and cycling facility improvements.* Improved sidewalks, crosswalks, paths, bikelanes, bicycle parking and changing facilities. Apply *universal design*, which refers to design features that accommodate all possible users, including wheelchair and handcart users, and people who cannot read local languages.
- *Active transport encouragement and safety programs.* Special programs that encourage people to walk and bicycle for transport, and teach safety skills.
- *Public bikes* (easy-to-rent bikes distributed around a community).
- *Roadway redesign, including traffic calming, road diets, and traffic speed controls.* Traffic calming changes roadway design to reduce traffic speeds. Road diets reduce the number of traffic lanes, particularly on urban arterials. Traffic speed controls can involve driver information, changes in posted speed limits, and increased enforcement.
- *Improved road and path connectivity*. More connected roadway and pathway systems allow more direct travel between destinations. Walking and cycling shortcuts are particularly effective at encouraging motorized to active travel shifts.
- *Public transport improvements*. Public transport complements active transport: Public transit improvements often involve pedestrian and cycling facility improvements (such as better sidewalks and bicycle parking), and it can reduce vehicle traffic and sprawl.
- *Commute trip reduction programs*. This includes various programs that encourage use of alternative modes, particularly for commuting to work and school. These often include features that encourage active travel such as improving bicycle parking or financial rewards such as *parking cash out*.
- *Pricing reforms.* This includes more efficient road, parking, insurance and fuel pricing (motorists pay directly for costs they impose).
- *Smart growth (also called new urban, transit-oriented development, and location-efficient development) land use policies.* More compact, mixed, connected land use, and reduced parking supply tends to improve walking and cycling conditions and encourage use of active modes by reducing the distances people must travel to reach common destinations such as shops, schools, parks, public transit, and friends.

Table 3 summarizes the travel impacts of these strategies. Some strategies only affect a portion of total travel (for example, Commute Trip Reduction programs only affect commute travel at participating worksites). A combination of these strategies can have significant impacts, improving active travel conditions, increasing active travel, and shifting 10-30% of motorized travel to active modes.

Table 3 **Travel Impacts of Strategies to Encourage Active Travel**

Strategy	Improves Active Conditions	Increases NMT Travel	Reduces Automobile Travel
Walking & cycling facility improvements	Significant	Significant	Moderate
Encouragement and safety programs	Moderate	Moderate	Moderate
Public bikes	Moderate	Moderate	Moderate
Roadway redesign	Moderate	Moderate	Small
Improving road and path connectivity	Significant	Significant	Significant
Public transport improvements	Moderate	Moderate	Moderate
Commute trip reduction	Moderate	Moderate	Significant
Transportation price reforms	Small	Moderate	Significant
Land use policy reform	Significant	Significant	Significant

("Small" = less than 1%; "Moderate" = 1-5%; "Significant" = greater than 5%)

This table summarizes the potential impacts of various mobility management strategies. Although many strategies have modest individual impacts, their effects are cumulative and often synergistic (total impacts are greater than the sum of individual impacts). An integrated program that combines several appropriate strategies can significantly improve active mode conditions, increase active travel and reduce automobile travel.

Conversely, planning decisions such as roadway expansion, increased traffic volumes and speeds, automobile travel underpricing, and sprawled development tend to degrade walking and cycling conditions and discourage their use.

Network and Synergistic Effects

Transport systems tend to have network effects: their impacts and benefits increase as they expand. For example, a single sidewalk or bicycle lane generally provides little benefit since it will connect few destinations, but a network of sidewalks and bicycle lanes that connect most destinations in an area can be very beneficial. Similarly, a single sidewalk or bicycle path that connects two networks (i.e., it fills a missing link) can provide very large benefits.

Transportation improvement strategies also have synergistic effects, that is, their total impacts are greater than the sum of their individual impacts. For example, developing bike lanes alone may only increase bicycle commute mode share by 5-points, and a commute trip reduction program alone may only increase bicycle mode share by 5-points, but implemented together they may increase bicycle mode share by 15-points because of their synergist effects.

Conventional transport planning often evaluates projects and programs individually, and so tends to overlook these network and synergistic effects. This tends to undervalue active transport improvements, particularly early in the development period. The first few sidewalks, bike lanes or encouragement programs in a community will seldom offer a high economic return if evaluated individually, although once completed the network may provide very large benefits. It is therefore important to use comprehensive and systematic evaluation of active mode benefits.

Active Planning Resources

AASHTO (2004), *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, American Association of State Highway and Transportation Officials (www.aashto.org).

Nelson\Nygaard (2009), *Abu Dhabi Urban Street Design Manual*, Urban Planning Council (www.upc.gov.ae); at www.upc.gov.ae/guidelines/urban-street-design-manual.aspx?lang=en-US.

ABW (2010 and 2012), *Bicycling and Walking in the U.S.: Benchmarking Reports*, Alliance for Biking & Walking (www.peoplepoweredmovement.org); at www.peoplepoweredmovement.org/benchmarking.

Alta Planning (2005), *Caltrans Pedestrian and Bicycle Facilities Technical Reference Guide*, California DOT (www.dot.ca.gov/hq/traffops/survey/pedestrian/TR_MAY0405.pdf).

Bicycle Information Center (www.bicyclinginfo.org), provides nonmotorized planning information.

Bicyclepedia (www.bicyclinginfo.org/bikecost), bicycle facility benefit/cost analysis tool.

Complete Streets (www.completestreets.org), provides information on multi-modal road planning.

FHWA Bicycle and Pedestrian Program Office (www.fhwa.dot.gov/environment/bikeped) promotes bicycle and pedestrian accessibility, use and safety.

Fietsberaad (www.fietsberaad.nl), the Dutch *Centre of Expertise on Bicycle Policy* develops and disseminates practical knowledge and experience for improving and encouraging cycling.

GTZ (2009), *Cycling-inclusive Policy Development: A Handbook*, Sustainable Urban Transport Project (www.sutp.org/index.php?option=com_content&task=view&id=1462&Itemid=1&lang=uk)

ITE (2010), *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, Institute of Transportation Engineers (www.ite.org/css); at www.ite.org/emodules/scriptcontent/Orders/ProductDetail.cfm?pc=RP-036A-E.

PBIC (2009), *Assessing Walking Conditions With An Audit*, Pedestrian and Bicycle Information Center (www.walkinginfo.org); at www.walkinginfo.org/problems/audits.cfm.

PROWAC (2007), *Accessible Public Rights-of-Way: Planning and Designing for Alterations*, Access Board (www.access-board.gov); at www.access-board.gov/prowac/alterations/guide.htm.

VTPI (2010), Online TDM Encyclopedia, Victoria Transport Policy Institute (www.vtpi.org/tdm).

Walk Friendly Communities (www.walkfriendly.org) is a USDOT program that encourages communities to create safer walking environments.

WFC (2010), *Walk Friendly Community Assessment Tool*, Walk Friendly Communities (www.walkfriendly.org).

Charles V. Zegeer, Laura Sandt and Margaret Scully (2009), *How to Develop a Pedestrian Safety Accident Plan*, National Highway Traffic Safety Administration, U.S. Federal Highway Administration; at http://safety.fhwa.dot.gov/ped_bike/docs/fhwasa0512.pdf.

Benefit and Cost Categories

Active transportation can provide various types of benefits and costs, depending on their impacts, as summarized in Table 4. Some of these overlap. For example, many economic development benefits result from the transport and infrastructure cost savings. It is therefore important to avoid double-counting total benefits.

Table 4 **Active Transportation Benefits and Costs**

	Improved NMT Conditions	Increased NMT Transport Activity	Reduced Automobile Travel	More Compact Communities
Potential Benefits	• Improved user convenience and comfort • Improved accessibility for non-drivers, which supports equity objectives • Option value • Higher property values • Increased security	• User enjoyment • Improved public fitness and health • Increased community cohesion (positive interactions among neighbors due to more people walking on local streets) which tends to increase local security	• Reduced traffic congestion • Road and parking facility cost savings • Consumer savings • Reduced chauffeuring burdens • Increased traffic safety • Energy conservation • Pollution reductions • Economic development	• Improved accessibility, particularly for non-drivers • Transport cost savings • Reduced sprawl costs • Openspace preservation • More livable communities • Higher property values • Improved security
Potential Costs	• Facility costs • Lower traffic speeds	• Equipment costs (shoes, bikes, etc.) • Increased crash risk	• Slower travel	• Increases in some development costs

Active transport can have various benefits and costs.

Table 5 summarizes factors that affect the magnitude of these impacts.

Table 5 **Factors Affecting Active Transport Benefits and Costs**

Category	Factors Affecting Their Magnitude
Improved walking and cycling conditions.	Degree of improvement. Number and type of potential users. Whether many pedestrians and cyclists depend on these modes for basic mobility.
Increased walking and cycling activity	Amount walking and cycling increases. Number and type of users. Whether currently sedentary people increase their physical activity.
Reduced automobile travel	Amount and type of automobile travel reduced (reductions in urban-peak travel tend to provide large benefits).
Land use impacts.	Degree that a policy or project supports land use planning objectives.
Costs	Project costs. Vehicle traffic delays. Users' incremental financial, time and risk costs, and whether users have good alternatives.

This table summarizes factors that affect the magnitude of active transport benefits and costs.

Monetization Methods
Some NMT impacts involve *non-market goods*, that is, goods not generally traded in a competitive market. For example, improved pedestrian environments, cleaner air, and reduced traffic risk are not generally purchased directly by consumers. Various methods can be used to *monetize* (measure in monetary units) such impacts (van Essen, et al. 2007; "Quantification Techniques," Litman 2009):

- *User savings.* Active mode improvements that allow people to reduce their transport costs (vehicle ownership and operation, parking costs, etc.) can be considered worth at least those monetary savings.
- *Social cost savings.* Active improvements that reduce costs to government or businesses (such as reduced road or parking facility costs) can be considered worth that amount to a community.
- *Control costs.* A cost can be estimated based on prevention, control or mitigation expenses. For example, if industry is required to spend $1,000 per ton to reduce emissions of a pollutant, we can infer that society considers those emissions to impose costs at least that high. If both damage costs and control costs can be calculated, the lower of the two are generally used for analysis on the assumption that a rational economic actor would choose prevention if it is cheaper, but will would accept damages if prevention costs are high.
- *Contingent valuation surveys* ask people the amount they would willingly pay for a particular improvement, or the amount they would need to be compensated for loss, such as the closure of a path or trail (Carleyolsen, et al. 2005). Most communities spend approximately a hundred dollars annually per capita on local parks and recreation centers. This suggests that walking and cycling improvements that significantly improve people's ability to enjoy recreational walking and cycling provide benefits of comparable value.
- *Revealed preference studies* observe how much people pay in money or time to access services or facilities. For example, if somebody spends 20 minutes and two dollars for fuel to drive to a trail to walk or bike, this suggests they value trail use more than those costs, and they might be willing to pay to help develop a closer trail that is cheaper to access.
- *Hedonic pricing studies* observe how walking and cycling improvements affect nearby property values. For example, Cortright (2009) found that in typical U.S. metropolitan regions a one point increase in Walkscore (www.walkscore.com) is associated with a $700 to $3,000 increase in home values, indicating the value consumers place on walkability.
- *Compensation Rates*. Legal judgments and other damage compensation can be used as a reference for assessing nonmarket values. For example, if crash victims are compensated at a certain rate, this can be considered to indicate damage costs. However, some damages are never compensated, and it would be poor public policy to fully compensate all such damages, since that could encourage some people (those who put a relatively low value on their injuries) to take excessive risks or even cause crashes in order to receive compensation. As a result, compensation costs tend to be lower than total damage costs.

In some situations a combination of methods should be used. For example, the total value of health benefits may include a reduction in government, business and consumer healthcare costs; reduced worker disability costs and improved productivity; users' willingness-to-pay for reduced illness and longevity; minus any increase in medical costs associated with walking and cycling.

User Benefits

Improving active mode conditions (better sidewalks, crosswalks, paths, bike parking, traffic speed reductions, etc.) directly benefits *existing users* (people who would walk or bicycle even without improvements) and *new users* (people who increase walking or cycling in response to improvements). Just as a faster or safer roadway benefits motorists, safer and more convenient walking and cycling conditions benefits users of those modes. User benefits can be large for the following reasons:

- Active travel is a critical component of the transport system. It is typically the second most common mode of transport (after automobile travel), and provides access to and connections among other modes. As a result, improving walking and cycling conditions can improve overall transport system diversity and efficiency.
- Active transport provides basic mobility, alone and in conjunction with public transport. In a typical community, 20-40% of residents cannot drive due to age, disability or poverty, and so depend on non-automobile modes, or are forced to rely on motorists for rides. As a result, the quality of NMT affects mobility disadvantaged people's ability to access critical goods and activities, and their independence.
- Pedestrian environments serve many functions and are a critical part of the public realm (public spaces where people naturally interact). On sidewalks and paths people stand, wait, socialize, play, eat, work and window-shop, and these facilities are an important part of the landscape. Improving pedestrian environments can improve the utility and enjoyment of these activities, and create more attractive communities.
- Although active travel represents only 5-15% total trips, it represents a larger portion of travel time (typically 15-30%), which is how users experience transport, so NMT travel conditions significantly affect people's travel experience.
- Active modes provide enjoyment and exercise. Even utilitarian trips often provide such benefits. Surveys indicate that walking and cycling are among the most common forms of recreation, and that many people would like to use these modes more, provided that NMT conditions improve (ABW 2010).

Evaluation methods: Various methods can be used to measure the value to users of walking and cycling improvements:

- *Avoided costs* (user savings from reduced expenditures on motorized travel or exercise equipment). Walking and cycling improvements reduce consumer expenditures on automobiles, taxi and public transit fares, exercise equipment or gym memberships. In some situations (for example, where active mode improvements reduce the need for households to own vehicles) savings can total hundreds or thousands of dollars annually per capita.
- *Contingent valuation* (user surveys). Area residents or potential users can be surveyed to determine their willingness-to-pay for specific facilities or improvement. This method is often used to estimate park and trail values (Carleyolsen, et al. 2005).
- *Hedonic pricing* (effects of walking and cycling improvements on nearby property values). Various studies indicate that walkability improvements tend to increase local property values (Bartholomew and Ewing 2011; Cortright 2009; Krizek et al. 2006; LGC 2001).

Buchanan (2007) found that residential property values are 5.2% higher and retail rents 4.9% higher in more walkable London neighborhoods. Song and Knaap (2003) found that, all else being equal, house values are 15.5% higher in walkable neighborhoods. Eppli and Tu (2000) found 11% higher property values in New Urbanist neighborhoods compared with otherwise similar homes in conventional, automobile-dependent communities.

Cortright (2009) found that a one-point Walkscore increase is associated with a $700 and $3,000 increase in home resale value, so a 10-point increase raises annualized housing costs approximately $350-$1,500. Pivo and Fisher (2010) found that office, retail and apartment values increased 1% to 9% for each 10-point WalkScore increase. Assuming a 10-point Walkscore increase causes average daily walking to increase one-mile per household (0.4 miles per capita), this indicates that consumers willingly pay $1 to $4 in higher housing costs per additional mile walked. Similar impacts are found in Canadian cities. In Calgary, Alberta found that between 2000 and 2012 the neighborhoods with the greatest home price increases were in or near the city's core with higher walkscore (Toneguzzi 2013). A real estate market study in Edmonton concluded that "A high walkability score is a big draw for potential buyers. Current market turbulence means people are looking to save money any way they can." (Campbell, Reuter and Epp 2010). Of course, the positive correlation between WalkScore and property values may partly reflect other factors such as land use density, transit accessibility, and employment access.

Residential property values also tend to increase with proximity to public trails (NTTP 2005; Racca and Dhanju 2006). Karadeniz (2008) found that each foot closer to Ohio's Little Miami Scenic Trail increases single-family property sale prices $7.05, indicating that values increase 4% if located 1,000 feet closer to the trail (this paper provides a good overview of the literature on this subject). Some studies indicate that proximity to trails and bike paths reduces the value of abutting properties, due to concerns over reduced privacy and increased crime (Krizek 2006). However, Racca and Dhanju (2006) conclude, "The majority of studies indicate that the presence of a bike path/trail either increases property values and ease of sale slightly or has no effect." Paths and trail benefits are likely to be largest in communities where walking and cycling are widely accepted and supported, and if residents can self-select, so people who value walking and cycling can locate near such facilities, while people who dislike such facilities can move away.

In general, the greater the improvement, the greater the benefit per user, and the more users the greater the total benefits. This benefit can be worth as much as $0.50 per user-mile (i.e., one person walking or bicycling one mile under improved walking and cycling conditions) where walking and cycling conditions improve from very poor to very good, based on evidence from hedonic pricing studies and avoided cost analysis (such as savings to parents who avoid the need to chauffeur children to school). In most cases, NMT improvement user benefits will be somewhat smaller, perhaps $0.25 per passenger-mile.

Option Value

Option value refers to the value people may place on having an option available that they do not currently use, such as the value ship passengers place on having lifeboats available for emergency use ("Transport Diversity," Litman 2009). Because walking and cycling can serve various roles in a transport system, including basic mobility for non-drivers, affordable transport, recreation and exercise, their potential option value is high.

Evaluation methods: Option value can be quantified using contingent valuation surveys which ask people how much they would be willing to pay for walking and cycling facilities and services that they do not currently use. The UK Department for Transport developed specific guidance for evaluating option value (DfT 2003). The "Transport Diversity Value" chapter of *Transportation Cost and Benefit Analysis* (Litman 2009) estimates that improvements in affordable alternative modes can be valued at 7¢ per passenger-mile, although this value can vary significantly depending on conditions and assumptions.

Equity Benefits

Equity refers to the distribution of impacts and the degree that they are considered appropriate and fair. Major categories of transportation equity include:

- *Horizontal equity* – assumes that people with similar abilities should be treated similarly. This implies that, unless specifically justified, people should bear similar costs and receive a similar share of public resources.
- *Vertical equity with regard to income* – assumes that policies should protect the interests of lower-income people.
- *Vertical equity with regard to transportation ability and needs* – assumes that policies should protect the interests of mobility impaired people (such as people with disabilities).

Improving active travel conditions can help achieve equity objectives by providing a fair share of resources to non-drivers and providing basic mobility for physically, economically and socially disadvantaged people (Litman 2004c). In most communities, 20-40% of the population cannot or should not drive due to disability, low incomes, or age. Walking and cycling facility improvements benefit existing users (people who currently walk and bicycle), plus new users (people who walk and bike more due to improvements).

The following tend to be particularly effective at achieving equity benefits:

- *Universal design*. This refers to special transport system design features to serve all possible users, including people with disabilities and other special needs.
- *Basic mobility*. This refers to transport that provides access to essential services and activities, such as healthcare, education, employment, basic shopping, and social activities.
- *Economic opportunity*. This refers to helping lower-income people access services and activities that support their economic development, such as education and employment.

- *Affordability*. This refers to people's ability to afford basic goods and services, and opportunities for savings to lower-income households. Walking, cycling and public transit improvements tend to increase transport system affordability.
- *Respect and dignity.* Because alternative modes tend to be stigmatized, programs that improve their social status tend to benefit disadvantaged people who rely on these modes.

Evaluation methods: Various objectives and impacts can be considered in transport equity analysis (Forkenbrock and Weisbrod 2001; Forkenbrock and Sheeley 2004; Litman 2004c):

- *Egalitarian equity* (everybody receives equal shares) suggests that active transport should receive an approximately proportional share of transport resources, measured either as mode share or per capita. For example, if active mode share is 12%, it would be fair to spend that portion of total transport budgets on non-motorized improvements; and if governments spend $500 annually per motorist on road and parking facilities, a comparable amount should be spent on facilities or non-drivers.
- *Cost allocation equity* (each user group should pay their share of costs) suggests that public expenditures on active facilities should be comparable to what users pay in taxes.
- *Impact compensation* (people should compensate the harms they impose on others). To the degree that motor vehicle traffic imposes delay, risk or discomfort on active modes, there is a horizontal equity justification for motorists to finance active facilities to mitigate such impacts. To the degree that sidewalks, crosswalks and pedestrian overpasses are needed to protect pedestrians and cyclists from motor vehicle traffic impacts, it is fair that motorists should bear the costs of these facilities.
- *Vertical equity* (policies should favor disadvantaged people) suggests that special effort to improve non-motorized conditions is justified to the degree that these modes provide basic mobility for physically, economically and socially disadvantaged people. For example, traffic calming and speed control, and funding cycling facilities with motor vehicle user fees, help achieve vertical equity objectives by reducing the negative impacts that automobile traffic imposes on active mode users.

Various methods can help determine the value a community places on social equity objectives, and the degree that a particular policy or project helps achieve these objectives. For example, contingent valuation surveys can determine the amount community members are willing to pay to improve economically and physically disadvantaged people's access. Census and survey data can identify where disadvantaged populations live and travel, and therefore where such benefits are likely to be greatest.

Transit subsidies can indicate society's willingness-to-pay to provide basic mobility for non-drivers. Such subsidies average about 60¢ per transit passenger-mile, about half of which are justified to provide basic mobility for non-drivers (the other half is intended to reduce congestion, parking and pollution problems), indicating that basic mobility is worth at least 30¢ per passenger-mile to society.

Physical Fitness and Health

Active travel provides fitness and health benefits (Pucher, et al. 2010). Even small increases in physical activity can improve public health (Sallis, et al. 2004). Experts recommend that adults spend at least 150 minutes per week (22 minutes per day) in moderate physical activity, with additional health benefits if the exercise is more rigorous and longer duration (CDC 2010).

Diseases Associated With Inadequate Physical Activity

- Heart disease
- Hypertension
- Stroke
- Depression
- Diabetes
- Osteoporosis (weak bones and joints)
- Cancer
- Dementia

Although there are many ways to be physically active, walking and cycling are among the most practical and effective, particularly for inactive and overweight people (Sevick, et al. 2000; Pucher and Beuhler 2010; Bassett, et al. 2011). The U.S. Center for Disease Control's *Healthy People 2020* program includes specific objectives to increase walking and cycling (www.healthypeople.gov, PAF 10 and PAF 11). Residents of more multi-modal communities exercise more and are less likely to be overweight than in automobile-oriented communities (Ewing, Schieber and Zegeer 2003; Frank 2004). Analysis of 11,041 high-school students in 154 U.S. communities found that their odds of being overweight or obese decreased if they lived in more walkable communities (Slater, et al. 2013). Increased walking appears to reduce long-term cognitive decline and dementia (Erickson, et al. 2010).

A major ten-year study found that the overall health of residents of new housing developments improved when their daily walking increased as a result of more access to parks, public transport, shops and services (Giles-Corti, et al. 2013). Rojas-Rueda, et al. (2011) quantified the overall health impacts to users from shifting urban driving to cycling, including changes in accident risk, pollution exposure and public fitness. The study concluded that Barcelona's *Bicing* public bike rental system causes 0.03 additional annual traffic accident deaths, 0.13 additional air pollution deaths, and 12.46 fewer deaths from improved fitness, resulting in 12.28 deaths avoided and a 77 benefit:risk ratio. This does not account for the additional health benefits from reduced accident risk and reduced air pollution exposure to other residents. The authors conclude that public bicycle sharing schemes can help improve public health and provide other benefits.

Grabow, et al. (2011) estimated changes in health benefits and monetary costs if 50% of short trips were made by bicycle during summer months in typical Midwestern U.S. communities. Across the study region of approximately 31.3 million people, mortality is projected to decline by approximately 1,100 annual deaths. The combined benefits of improved air quality and physical fitness are estimated to exceed $7 billion/year. These findings suggest that significant health and economic benefits are possible if bicycling replaces short car trips.

Rabl and de Nazelle (2012) estimate the health impacts caused by shifts from car to bicycling or walking, considering four effects: changes in physical fitness and ambient air pollution exposure to users, reduced pollution to other road users, and changes in accident risk. Switching from driving to bicycling for a 5 km one-way commute 230 annual days provides physical activity health benefits worth 1,300 € annually and air emission reduction worth 30 €/yr. overall. The commuter that switches mode bears additional air pollution costs averaging 20 €/yr, but this impact depends on cycling conditions; cyclists' pollution exposure can be reduced if they ride separated from major roadways. Data from Paris and Amsterdam imply that any increase in accident risk is at least an order of magnitude smaller than physical activity health benefit.

Evaluation methods: Some studies monetize the health benefits of improved walking and cycling ("Safety and Health," Litman 2009; Boarnet, Greenwald and McMillan 2008; SQW 2007; Cavill, et al. 2008; NZTA 2010). Cavill, Cope and Kennedy (2009) estimated that an integrated program that increases walking in British towns provides benefits worth £2.59 for each £1.00 spent, considering just reduced mortality. Including other benefits (reduced morbidity, congestion and pollution) would increase this value. The Department for Transport found even higher economic returns (DfT 2010). The *Active Transport Quantification Tool* (ICLEI 2007) and the *Health Economic Assessment Tool for Cycling and Walking* (WHO 2011) provide methodologies for valuing the active transportation benefits, including savings from avoided driving, increased happiness, and reductions in coronary heart disease, diabetes risk, congestion, pollution and crash risk.

Guo and Gandavarapu (2010) conclude that the incremental costs of residential sidewalk construction are usually repaid by the health benefits of increased physical fitness and reduced vehicle air pollution. They estimate that building sidewalks on all city streets would increase average daily active travel 0.097 miles and reduce automobile travel 1.142 vehicle-miles per capita. The increased walking and cycling provide 15 kcal/day per capita in average additional physical activity, predicted to offset weight gain in about 37% of residents, providing substantial healthcare cost savings.

Gotschi (2011) estimated that Portland, Oregon's 40-year $138-605 million bicycle facility investments provide $388-594 million healthcare savings, $143-218 million fuel savings, and $7-12 billion in longevity value, resulting in positive net benefits. Sælensminde (2002) estimates that each physically inactive person who starts bicycle commuting provides €3,000-4,000 annual economic benefits. Meta-analysis by de Hartog, et al. (2010) indicates that people who shift from driving to bicycling enjoy substantial health benefits (3 to 14 month longevity gains), plus additional benefits from reduced air pollution and crash risk to other road users. The New Zealand Transport Agency's *Economic Evaluation Manual* provides these values of improved health and reduced congestion from active transport:

Table 6 **Active Transportation Health Benefits** (NZTA 2010, Vol. 2, p. 8-11)

	2008 $ NZ/km	2008 USD/mile
Cycling	$1.40	$1.92
Walking	$2.70	$3.70

This table indicates New Zealand's estimated value of increased walking and cycling.

Vehicle Savings

Reducing vehicle ownership and use can provide various types of savings, summarized in Table 7. Short urban trips tend to have high costs due to cold starts and congestion.

Table 7 **Vehicle Costs** ("Vehicle Costs," Litman 2009; Polzin, Chu and Raman 2008)

Category	Description	How It Can Be Measured	Typical Values
Vehicle operating costs	Fuel, oil and tire wear.	Per-mile costs times mileage reduced.	10-15¢ per vehicle-mile. Higher in congested conditions
Mileage-related depreciation	Mileage-related depreciation, repair costs and lease fees.	Per-mile costs times mileage reduced.	5-15¢ per vehicle-mile, depending on vehicle type.
Special costs	Tolls, parking fees, etc.	Specific market conditions.	Varies.
Vehicle ownership	Reductions in fixed vehicle costs.	Reduced vehicle ownership times vehicle ownership costs.	$2,000 to $3,000 per vehicle-year.
Residential parking	Reduced residential parking costs	Reduced vehicle ownership times costs per space.	$100-1,200 per vehicle-year.

Reducing automobile travel can provide various types of savings, depending on conditions.

Evaluation methods: Savings can be estimated using values from Table 7. Savings tend to be particularly large for reductions in short urban trips, and additional savings can occur if non-motorized improvements help create more accessible, multi-modal communities, which leverage additional reductions in vehicle travel, ownership and parking costs.

Reduced Chauffeuring Burdens

Chauffeuring (also called *escort*) trips refers to additional vehicle travel specifically to transport a passenger, as opposed to *ridesharing* in which a passenger rides in a vehicle that would travel anyway. Chauffeuring is particularly inefficient because it often requires empty return trips, so transporting a passenger 5 miles generates 10 vehicle-miles. Improving alternative modes can reduce chauffeuring burdens, saving driver travel time, vehicle operating costs, and external costs, and increasing non-drivers' independence. Although data are limited, chauffeuring appears to represent about 10% of total vehicle trips (TfL 2011), and is probably higher in automobile-dependent communities, and lower in multi-modal communities where adolescents, people with minor impairments, and people who cannot afford to own a motor vehicle have good mobility options.

Evaluation methods: Reduced chauffeuring benefits include previously described vehicle cost savings, driver travel time savings that are typically estimated at 30-50% of average wage rates, and reduced external costs (congestion, accident risk and pollution). Assuming that a typical chauffeuring trip involves 5 miles of vehicle travel at 25¢ per mile in vehicle costs, and 20 minutes of travel time valued at $9.00 per hour, this totals $4.25 per trip or $0.85 per vehicle-mile. This report's Option and Equity value sections describe methods for valuing increased independence to non-drivers.

Congestion Reduction

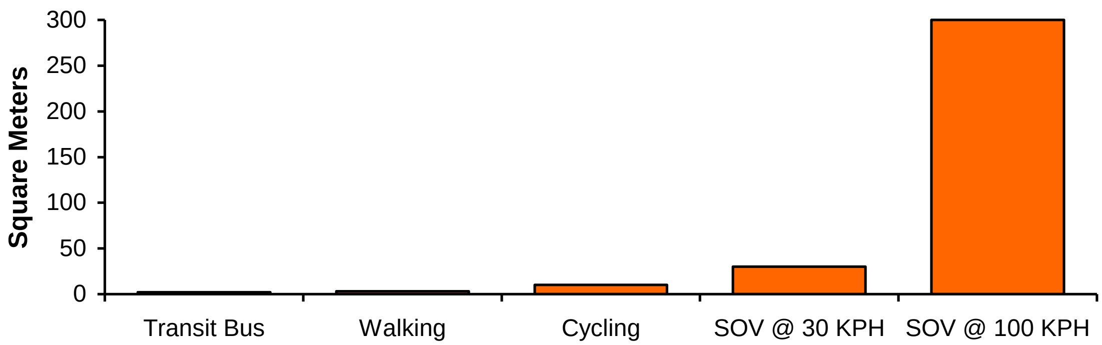
Traffic congestion costs consist of the incremental travel time, vehicle operating costs, stress and pollution emissions that a vehicle imposes on other road users ("Congestion Costs," Litman 2009). Walking and cycling conditions can affect vehicle trip generation in several ways:

- Poor walking and cycling conditions force people to drive for even short trips. In urban areas a significant portion of motor vehicle travel (often 10-30%) consists of short trips that could shift to active modes (Litman 2010). Were walking conditions are poor, such as along an urban arterial, people will drive even across the road or from one driveway to another, adding friction and cross traffic that creates delays.
- Poor walking and cycling conditions increases chauffeuring trips (special trips made to transport a non-driver) which often include empty backhauls, which also add congestion.
- Poor walking and cycling conditions discourage public transit and rideshare travel (car- and vanpooling), which reduces longer vehicle trips.

As a result, improving walking and cycling conditions can reduce automobile trip generation and therefore traffic congestion. These impacts tend to be greatest in commercial districts, and near schools and recreational centers, where many short trips begin and end.

Space requirements, and therefore congestion impacts, per passenger-mile or kilometer vary depending on vehicle (for this analysis people are considered vehicles) size, speed, and occupancy, and their interactions. Shy-distance (space between a vehicle and other objects) increases exponentially with speed, so at 30 kilometer-per-hour (KPH) vehicles can safety travel about 15 meters apart, but at 100 KPH they require about 150 meters. Space requirements are lowest when all vehicles travel at the same speed in the same direction, and decline with mixed speeds, counterflow and cross traffic. Some studies calculate the space requirements of various modes. According to one estimate, a pedestrian requires about 3 square meters, a cyclist about 10 square meters, an automobile at 30 KPH about 30 square meters and at 100 KPH about 300 square meters, and 50 transit bus passengers traveling at 30 KPH each require about 2 square meters (assuming a bus requires three passenger-car equivalents), as illustrated in Figure 7.

Figure 7 **Road Space Requirements By Mode** (based on Bruun and Vuchic 1995)



The space required per passenger varies depending on vehicle type, speed and travel conditions.

Non-motorized traffic can contribute to congestion. Pedestrians primarily cause delays when crossing or if roads lack sidewalks. Such impacts are generally less than if the same trips were made by automobile. To analyze the bicycling congestion impacts, roadway road conditions are divided into four classes:

1. *Uncongested roads and separated paths*. Bicycling in these conditions causes no congestion.
2. *Congested roads with space for bicyclists*. Bicycling on a road shoulder (common on highways), a wide curb lane (common in suburban and urban areas), or a bike lane contributes little traffic congestion except at intersections where vehicle turning maneuvers may be delayed. Table 8 summarizes these impacts.

Table 8 **Passenger-Car Equivalents for Bicycles by Lane Width** (AASHTO 1990)

	< 11 ft. Lane	11-14 ft. Lane	> 14 ft. Lane
Riding With Traffic	1.0	0.2	0.0
Riding Against Traffic	1.2	0.5	0.0

3. *Narrow, congested roads with low speed traffic.* Bicycling on a narrow, congested road where cyclists keep up with traffic (common on urban streets) probably causes less congestion than an average car due to bicycles' smaller size.
4. *Narrow, congested roads with moderate to high speed traffic*. Bicycling on a narrow, congested road where the rider cannot keep up with traffic and faster vehicles cannot easily pass can cause significant traffic delay.

Congestion is reduced when travelers shift from driving to bicycling under the first three conditions. Only under condition 4 does a shift fail to reduce congestion. This represents a small portion of cycling travel because most bicyclists avoid riding under such conditions if possible, and bicycling is forbidden altogether on freeways. Bike lanes that substitute for general traffic lanes may increase congestion, but in other cases bike lanes increase total roadway capacity. For example, New York City's Prospect Park West carried more people after a "road diet" converted a traffic lane to a bike path (NYDOT 2010).

Traffic congestion can be measured in various ways that lead to different estimates of its cost and the effectiveness of various congestion reduction strategies (Grant-Muller and Laird 2007; Litman 2013). For example, roadway *Level-of-Service* (LOS) and the *Travel Time Index* (TTI) measure vehicle traffic delay on a particular roadway. These indicators do not account for the congestion avoided by travelers who shift from driving to alternative modes or reduce their travel distances, and so they tend to underestimates the congestion reduction benefits of improvements to alternative modes and more compact development. *Per capita travel time* and *per capita congestion delay* are better indicators of total congestion impacts since they account for the congestion avoided if travelers shift mode or choose closer destinations ("Congestion Costs," Litman 2009). For example, complete streets roadway designs and more compact development tend to *increase* congestion measured using roadway LOS or the TTI, because these strategies increase the intensity of congestion on specific roadways, but because they reduce automobile mode share and trip distances, these strategies *reduce* per capita travel time and congestion delays. Similarly, policies that prohibit pedestrian crossings on a roadway may reduce delay to motorists at that location, but increase automobile trips (travelers shift from walking to driving) and travel distances, increasing the total amount of time people spend traveling.

Most traffic models are designed to evaluate regional travel conditions, and so measure congestion on major arterials and highways. They do not generally account for local congestion impacts, and therefore much of the congestion reduction benefits of improving walking and cycling conditions. For example, few models can account for the congestion reduction benefits that result if youths shift from being driven to walking and cycling to school because much of the traffic reduction will occur on local streets that are not considered in traffic models. Traffic congestion tends to maintain equilibrium: delays increase to the point that they discourage additional peak-period vehicle trips. As a result, marginal increases in roadway capacity or incentives for a few trips to shift mode generally provide only short-term congestion reductions; long-term reductions require significant improvements in alternative modes or pricing reforms that change the point of equilibrium. Improving walking and cycling conditions tends to reduce household vehicle ownership and trip generation, which tends to reduce traffic congestion, but most research on this subject concerns public transit, active modes can have similar impacts, alone and in conjunction with transit (Litman 2004; Aftabuzzaman, Currie and Sarvi 2010).

Although available research is limited, there is evidence that walking and cycling improvements do reduce traffic congestion (SQW 2007). For example, a major study for the Arizona Department of Transportation analyzed the relationships between land use patterns and traffic conditions in Phoenix, Arizona (Kuzmyak 2012). It found significantly less congestion on roads in older, higher density areas than in newer, lower density suburban areas due to more mixed land use (particularly more retail in residential areas), more transit and nonmotorized travel, and a more connected street grid which provides more route options and enables more walking and cycling. As a result, residents of older neighborhoods generate less total vehicle travel and drive less on major roadways, reducing traffic congestion.

Evaluation methods: Reductions in urban-peak automobile travel tend to reduce traffic congestion. Various studies estimate that the congestion costs a motor vehicle imposes on other road users average 10¢ to 35¢ per urban-peak vehicle mile, with lower values under urban off-peak and rural travel conditions (Grant-Muller and Laird 2007; Litman 2009; TC 2006). SQW (2007) estimates that a traveler shifting from driving to cycling 160 annual trips averaging 3.9 kms reduces congestion costs to other road users £137.28 (£0.22 per km) in urban areas and £68.64 (£0.11 per km) in rural environments.

Barrier Effect

The *barrier effect* (also called *severance*) refers to the travel delay that vehicle traffic imposes on active modes ("Barrier Effect," Litman 2009). It is equivalent to traffic congestion imposed on non-motorized vehicles (most congestion cost estimates ignore active travel impacts). This reduces active mode accessibility, and causes shifts from non-motorized to motorized travel which increases external costs such as traffic and parking congestion. Various transport planning decisions affect the barrier effect:

- Highway expansion increases the barrier effect by widening roadways and increasing vehicle traffic volumes and speeds.
- Traffic calming, road diets, and traffic speed reductions tend to reduce the barrier effect.
- Mobility management strategies that reduce total vehicle traffic volumes, such as more efficient road, parking, insurance and fuel pricing, tend to reduce the barrier effect.
- Active mode improvements, such as paths and sidewalks separated from roadway, improved crosswalks, and sometimes pedestrian overpasses, can reduce the barrier effect.
- Land use changes that reduce the need for pedestrians and cyclists to cross major roadways (such as locating schools and shops within residential neighborhoods rather than where residents much cross or travel along a busy highway) can reduce barrier effects.

Conventional transport planning generally ignores these impacts. For example, roadway widening is often described simply as a transport *improvement*, which recognizes the reduced delay to motorists but ignores the additional delay that wider roads and increased motor vehicle traffic imposes on active travel. More comprehensive, multi-modal evaluation recognizes the tradeoffs involved in such decisions.

Evaluation methods: The barrier effect imposes direct costs on pedestrians and cyclists, and indirect costs by reducing walking and cycling activity and increasing motorized travel. The 2010 Highway Capacity Manual evaluates pedestrian and cycling level-of-service on a particular roadway (TRB 2010), and the UK Department for Transport roadway evaluation models quantify the barrier effect for specific situations by estimating walking and cycling demand assuming no barrier exists ("Barrier Effect," Litman 2009; DfT 2009; TRB 2008). These models calculate the demand for travel between local destinations (homes, schools, shops, parks, etc.) and the delay to active mode travelers caused by wider roads and increased motor vehicle traffic volumes and speeds.

Barrier effect costs are typically estimated to average 0.5¢ to 1.5¢ per urban automobile vehicle-mile, although they may be much higher where there is considerable walking and cycling demand. For example, if a busy road between homes and schools makes non-motorized travel so difficult that households purchase second cars to chauffeur children (even though they would prefer to walk or bicycle), the additional costs may total thousands of dollars annually for the additional vehicle expenses and external costs.

Roadway Costs Savings

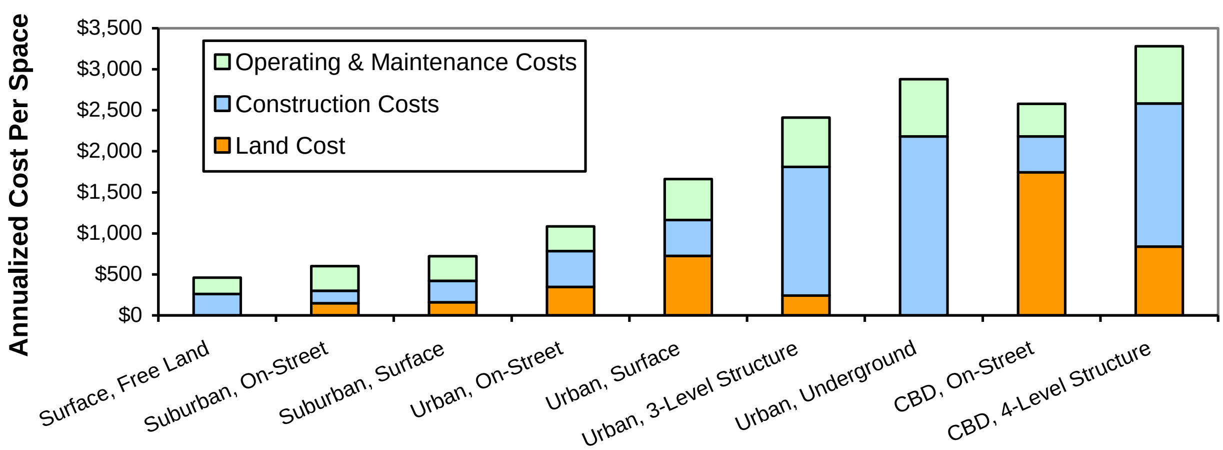
Roadway costs average about $550 annually per capita in the U.S., about half of which is funded through general taxes rather than user fees (FHWA 2008; Subsidy Scope 2009). In Canada, local roadway capital and operating costs are estimated to total $18.8 billion in 2000 (TC 2008, Table 3-4), which averaged about 9¢ per kilometer, assuming 200 billion annual local kilometers driven. Although roads serve both motorized and active travel, walking and cycling require less road space and impose less wear, and so cost less per mile of travel (FHWA 1997; "Roadway Costs," Litman 2009). Sidewalks and paths are relatively inexpensive to build and maintain. Providing non-motorized lanes sometimes require wider roads, but bicycle lanes are usually developed using existing road shoulders, parking lanes, or by narrowing traffic lanes. As a result, shifting travel from motorized to active modes generally reduces total roadway costs.

Evaluation methods: Roadway construction and maintenance costs are a function of vehicle size, weight, speed, and, in some regions, studded tire use (FHWA 1997). Roadway costs average about 4¢ per mile for automobiles and more for heavier vehicles ("Roadway Costs," Litman 2009). Walking and cycling impose minimal roadway costs. Shifts from driving to walking or bicycling provide roadway facility and traffic service cost savings of approximately 5¢ per mile for urban driving and 3¢ per mile for rural driving, including indirect travel reductions leveraged by active transport improvements.

Parking Cost Savings

A typical urban parking space has annualized costs (including land, construction and operating costs) totalling $500 to $3,000, as illustrated below, and there are estimated to be two to six off-street parking spaces (one residential and two non-residential) per motor vehicle ("Parking Cost" Litman 2009). Pedestrians only require umbrella stands and coat racks, and 10-20 bicycles can typically be stored in the space required for one automobile.

Figure 8 **Typical Parking Annualized Costs per Space** (Litman 2009)[1]



An urban parking space typically costs $500 to $3,000 in total annualized costs.

[1] *Parking Cost, Pricing and Revenue Calculator*, VTPI (www.vtpi.org/parking.xls).

In the short run, reductions in automobile travel may simply result in unoccupied parking spaces, but eventually most parking facilities have opportunity costs: reduced parking demand allows property owners to avoid expanding parking supply, or they can rent, sell or convert parking facilities to other uses.

Evaluation methods: Parking costs are not generally affected by trip length, so this cost is measured per trip rather than per mile. Shifting from automobile to active travel is estimated to provide parking savings of $2-4 per urban-peak trip (a typical commute has $4-8 per day parking costs), $1-3 per urban off-peak trip, and about $1 per rural trip ("Parking Costs," Litman 2009).

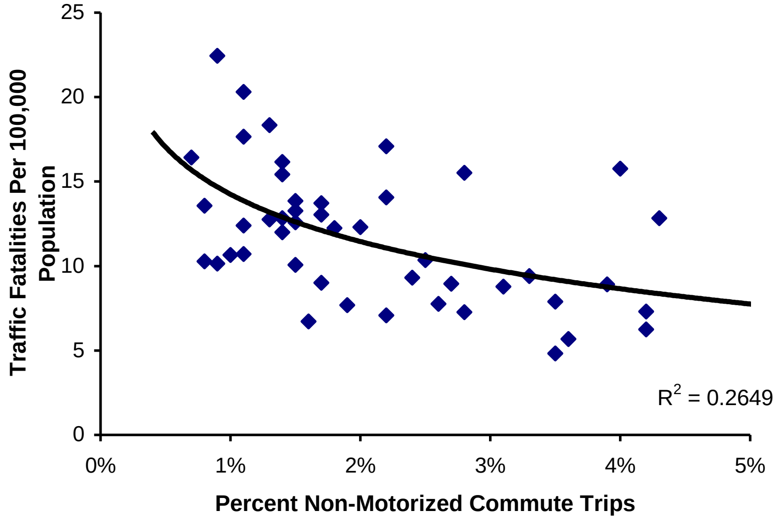
Traffic Safety Impacts

Crashes are among the largest transportation costs ("Crash Costs," Litman 2009; TC 2008; Vermeulen, et al. 2004). A portion of this cost is internal (a direct risk to the traveler), a portion is external (imposed on other road users), and a portion compensated by vehicle insurance, and therefore external to the individual traveler but internal to motorists as a group (Litman 2009). Although walking and cycling have higher per-mile casualty rates than automobile travel, shifting travel from automobile to active modes tends to reduce total crash costs due to the following factors (WHO 2008):

1. Active travel imposes minimal risk to other road users.
2. In automobile-dependent communities walking and cycling casualty rates are relatively high because many users are children and people with disabilities, who tend to have high risk factors. A pedestrian or cyclist who takes basic precautions such as observing traffic rules and wearing a cycling helmet tends to have much lower than average risk.
3. Per-mile and per capita traffic casualty rates tend to decline as walking and cycling activity increases in a community, because drivers become more cautious and communities invest more in non-motorized safety improvements where there are more pedestrians and cyclists.
4. As active travel increases, total per capita mileage declines. A local walking trip often substitutes for a longer automobile trip. People who rely on active modes tend to travel fewer total annual miles than motorists.
5. Some walking and cycling promotion programs include education and facility improvements that reduce participants' per-mile pedestrian and bicycle crash rates.
6. The substantial health benefits of walking and cycling (described earlier) more than offset any increase in crash risk, so longevity tends to increase with active transport.

Shifts from driving to active modes tend to reduce total per capita crash casualty rates in an area, as indicated in figures 9 and 10. Areas with high rates of walking and cycling, such as Germany and the Netherlands, have low per capita traffic death rates (Fietsberaad 2008; ABW 2010). Overall, longevity tends to increase with increased walking and cycling activity (Andersen, et al. 2000; Cavill, et al. 2008).

Figure 9 **Traffic Fatalities Vs. Active Transport** (US Census 2000)

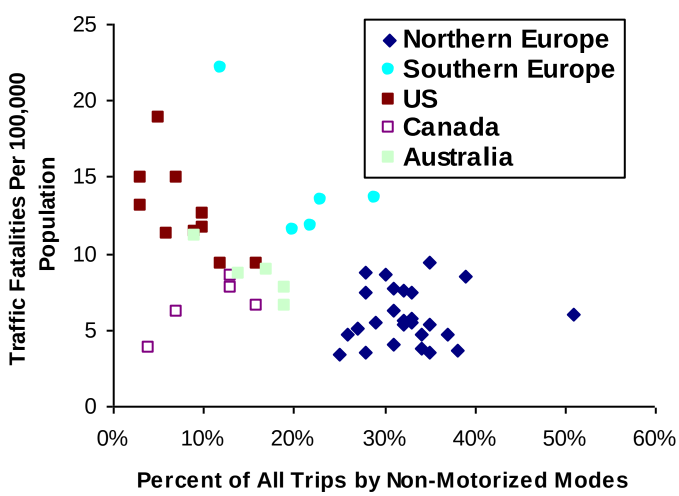


Per capita traffic fatality rates tend to decline as active travel increases. This is called "safety in numbers," (Jacobsen 2003)

Chu (2006) concludes that walking has 1.7 times the fatality rate per minute of travel than motor vehicle travel, with significant variation by time of day, age of walker and how risk is measured. The incremental risk for responsible pedestrian or cyclist who observes traffic rules and takes precautions such as using a light at night and a helmet (for cyclists) is likely to be much lower than indicated by average per-mile fatality rates, and offset by reductions in risk to other road users and other health benefits.

Jacobsen (2003) found that collision rates between motor vehicles and pedestrians and cyclists increases at roughly 0.4 power of walking and cycling activity (e.g., doubling NMT travel in a community will increase pedestrian/cycling injuries by 32%), a pedestrian's risk declines 34% if walking and cycling double in their community. Robinson (2005) found similar results in Australia.

Figure 10 **Traffic Fatalities Vs. Active Transport** (Kenworthy and Laube 2000)



Per capita traffic fatalities tend to decline as the portion of active urban travel increases.

Marshall and Garrick (2011) found that U.S. cities with higher per capita bicycling rates tend to have much lower traffic fatality rates for all road users than other cities. They conclude that this results, in part, because increased street network density both supports cycling and reduces traffic speeds and therefore risk. Robinson (2005), Geyer, Raford and Ragland (2006), and Turner, Roozenburg and Francis (2006) also find that shifts from driving to active modes by sober, responsible adults are unlikely to increase total accidents, and that per capita collisions between motorists, pedestrians and cyclists decline as active transport activity increases.

Evaluation methods: Various studies indicate that automobile external accident costs average 2¢ to 12¢ per vehicle-mile, depending on driver and travel conditions, and the scope of costs considered ("Crash Costs," Litman 2009; van Essen, et al. 2007; TC 2008). Net safety benefits provided by automobile to active travel shifts are estimated to average 5¢ per urban peak mile, 4¢ per urban off-peak mile, and 3¢ per rural mile, with greater benefits from strategies that reduce walking and cycling risk, for example if active travel increases due to more separated facilities (e.g., sidewalks and paths), traffic speed reductions, improved traffic law enforcement and cycling education.

Security Impacts

Security refers to freedom from assault, theft and vandalism. Many strategies for improving walking and cycling conditions can increase security, both directly, by increasing security patrols and trimming landscaping, and indirectly by increasing the number of responsible (non-criminal) people on sidewalks and paths, which increases passive surveillance (more people ready to report threats). Contrary to popular assumptions, per capita crime rates tend to decline in more compact, mixed, walkable communities, probably due to a combination of improved surveillance, better policing and emergency response, and improved economic opportunity for at-risk residents (Litman 2013).

Energy Conservation

Motor vehicle production and use consume large amounts of natural resources, particularly energy such as petroleum and coal (Chester and Horvath 2008). This consumption imposes various external costs, including economic and national security impacts from dependence on imported petroleum, plus environmental and health damages from pollution. As a result, resource conservation can provide various benefits (NRC 2009).

Active transport can provide relatively large energy savings because it tends to substitute for short urban trips that have high emission rates per mile due to cold starts (engines are inefficient during the first few minutes of operation) and congestion. As a result, each 1% shift from automobile to active travel typically reduces fuel consumption 2-4% (Komanoff and Roelofs 1993). In addition, as previously described, active transport tends to have leverage effects, so comprehensive programs to improve walking and cycling can provide additional energy conservation benefits.

Evaluation methods: Petroleum consumption external costs are estimated to be 1-4¢ per vehicle-mile ("Resource Consumption External Costs," Litman 2009; NRC 2009), although possibly more to account for all environmental costs associated with petroleum extraction. Relatively high values are justified because non-motorized travel substitutes for short urban trips in which motor vehicles are fuel inefficient due to cold starts and congestion.

Pollution Reduction

Motor vehicle production and use produce air, noise and water pollution which harm people, agricultural and the natural environment (Chester and Horvath 2008; TC 2008). Some pollutants, such as noise, carbon monoxide and particulates, have local impacts so their costs vary depending on where emissions occur, while others, such as ozone, methane and carbon dioxide, have regional and global impacts ("Air Pollution," Litman 2009). Walking and cycling produce virtually no pollution. Per mile emission reductions tend to be relatively large when active modes substitute for short urban trips which have high emission rates due to cold starts and congestion. Pedestrians and cyclists are exposed to vehicle pollution, although no more than motor vehicle occupants (Frank, et al. 2010).

Estimated Benefits: Various studies quantify and monetize motor vehicle pollution damages, but many of these estimates include only a limited portion of total pollution costs. For example, some consider ozone, CO and NOx damages but ignore particulate and air toxic damages, so total costs are higher than most published estimates (van Essen 2004). Automobile air, noise and water pollution costs are typically estimated to average 2¢ to 15¢ per vehicle-mile, with lower-range values in rural conditions and higher values under congested urban conditions, but relatively high values can be justified to reflect the tendency of walking and cycling to reduce short urban trips (Delucchi 2007; Litman 2009; TC 2008; Vermeulen, et al. 2004). A British study estimates that shifts from driving to active modes provide air pollution reduction benefits of £0.11 in urban areas and £0.02 in rural areas, with higher values for diesel vehicles (SQW 2007). A reasonable estimate is 10¢ per mile for urban-peak driving, 5¢ for urban off-peak and 1¢ for rural driving.

Land Use Impacts

Transportation planning decisions often affect land use development patterns (CTE 2008; Forkenbrock and Weisbrod 2001; Litman 1995). Planning decisions that favor automobile travel, such as expanded urban roadways with higher design speeds, increased parking requirements and lower vehicle user fees, tend to encourage more dispersed, urban-fringe development, called *sprawl*, while planning that favors walking, cycling and public transit tend to encourage more compact, mixed development, called *smart growth*.

This occurs because walking, cycling and public transit require more compact and mixed development for access, and these mode are more space-efficient than automobile travel. Table 9 compares road and parking space requirements of various modes for a typical commute. This indicates that driving requires approximately 15 times as much space as bicycling, and about 100 times as much as walking. Walking and cycling improvements also tend to enhance the *public realm* (public spaces where people naturally interact), which creates safer and more livable urban neighborhoods (Appleyard 1981).

Table 9 **Time-Area Requirements Per Commuter** (based on Bruun and Vuchic 1995)

Mode	Standing/ Parking	8 hr. Parking	Road Space	Per 20-minute Trip	Total (Parking & 2 Commutes)
	Sq. Ft.	*Sq. Ft.-Min.*	*Sq. Ft.*	*Sq. Ft.-Min.*	*Sq. Ft.-Min.*
Pedestrian	5	*0*	20	*400*	800
Bicycle	20	*9,600*	50	*1,000*	11,600
Bus	20	*0*	75	*1,500*	3,000
Automobile – 30 mph	300	*144,000*	1,000	*20,000*	184,000
Automobile – 60 mph	300	*144,000*	2,250	*45,000*	214,000

This table compares time-area requirements for parking and road space measured in square-foot-minutes (square feet times number of minutes) for 20-minute commutes by various modes.

Smart growth can provide various economic, social and environmental benefits, as summarized in Table 10. Most communities have objectives to encourage more compact development, redevelop urban neighborhoods, reduce impervious surface area, and preserve open-space (parks, farmland, forests, etc.), in order to achieve these benefits, regardless of whether or not they are called smart growth.

Table 10 **Smart Growth Benefits** (Burchell, et al. 2002; Litman 1995)

Economic	Social	Environmental
Reduced development and public service costs Consumer transportation cost savings Economies of agglomeration More efficient transportation	Improved transport options, particularly for nondrivers Improved housing options Community cohesion	Greenspace and habitat preservation Reduced air pollution Energy conservation Reduced water pollution Reduced “heat island” effect

This table summarizes various benefits to society of smart growth development patterns.

As a result, walking and cycling improvements can provide indirect, smart growth benefits. For example, a Safe Routes to School program that allows more students to walk and bike to school, provides both direct benefits from reduced automobile traffic, and indirect benefits by reducing the amount of land that must be paved for roads and parking facilities, and by encouraging school districts to place schools in central locations for maximum walking and cycling access.

Evaluation methods: These impacts are potentially large, although difficult to quantify. People who live and work in more compact and multi-modal communities tend to own fewer cars, drive less and rely more on alternative modes, which reduces both internal costs (the costs borne by residents) and external costs (costs imposed on others, such as traffic and parking congestion, accident risk and pollution emissions. In addition, more compact development tends to reduce infrastructure and environmental costs, and improve accessibility for non-drivers (CTE 2008). Together, these can provide thousands of dollars in annual savings and benefits per capita (Forkenbrock and Weisbrod 2001; "Land Use Impacts," Litman 2009).

These impacts tend to be difficult to evaluate because they are numerous (analyses often focus on a few but overlook others), some are difficult to quantify and monetize; and there are often several steps between a planning decision and its ultimate land use impacts. To evaluate these impacts:

1. Identify how a planning decision affects land use patterns, including direct impacts of transport facilities, and indirect impacts from changes in development patterns. This requires defining a base case (what would otherwise occur, if the proposed policy or project is not implemented).
2. Second, describe, and to the degree possible, quantify these land use changes, including differences in impervious surface coverage, impacts on farming and wildlife habitat, changes in accessibility and travel activity (such as more vehicle travel), and resulting changes in energy consumption and pollution emissions.
3. Third, to the degree possible, monetize these impacts. For example, estimate economic and environmental costs of increased pavement and reduced openspace. Some effects can be monetized by assigning a dollar value per hectare of habitat lost to development, or each additional motor vehicle-mile generated by sprawl.

This type of analysis requires making numerous assumptions about impacts and values, and the results may overlook some impacts, such as community cohesion and agglomeration economies, because they are difficult to quantify. Such assumptions should be documented. It may be better to incorporate some impacts qualitatively, through descriptions and community involvement, rather than assigning a single total dollar value to total land use impacts (Louis Berger Inc. 1998). Rogers, et al. (2010) use a case study approach to evaluate the impacts of walkable social capital. Residents living in neighborhoods of varying built form and thus varying levels of walkability in three communities in New Hampshire were surveyed about their levels of social capital and travel behaviors. The results indicate that levels of social capital are higher in more walkable neighborhoods.

Economic Development

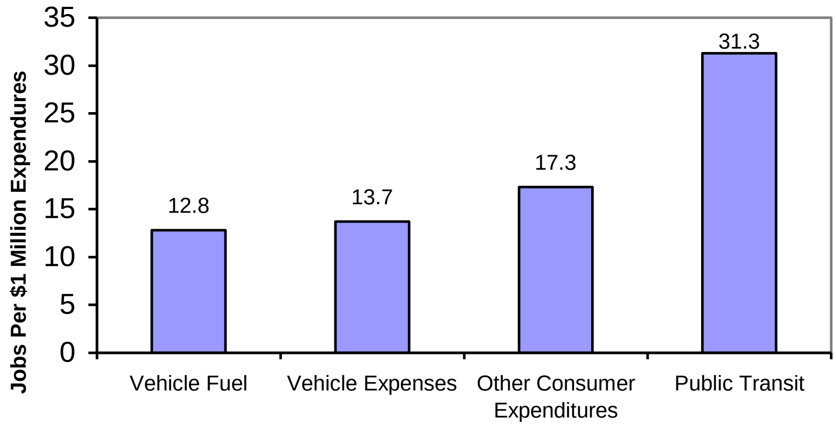
Economic development refers to progress toward community economic goals such as increased employment, income, productivity, property values and tax revenues. Active transport can support economic development in several ways (Buis 2000; Flusche 2012; Grous 2010; Litman 2011; NCDOT 2004; Living Streets 2011; Walk Boston 2011):

- *Transport efficiency*. Walking and cycling improvements can increase transport system efficiency by reducing costs such as traffic congestion, road and parking facility costs, and accident damages, as described previously in this report. To the degree that this reduces costs to commuters, businesses and governments it can increase economic productivity and competitiveness.
- *Labor productivity.* Walking and cycling improvements (alone and with public transit improvements) tends to improve access to education and employment opportunities, particularly by non-drivers, increasing the quantity and quality of the lower-wage labor pool, which can reduce business costs and increase productivity and competitiveness. Improving affordable transport options tends to expand the labor pool for industries that require numerous lower-wage employees, such as hospitality and light manufacturing.
- Increase labor productivity by increasing worker fitness and reducing sick leave (Chapman 2005; Henderson, et al. 2010).
- *Land use efficiency.* As previously described, walking and cycling support more compact, multi-modal development, which can provide various accessibility benefits, agglomeration efficiencies, and resource cost savings.
- *Consumer expenditures.* Impacts on consumer spending, particularly vehicles and fuel expenditures, which affect regional economic activity (Cortright 2007; Flusche 2012).
- *Supports specific industries*. Certain industries benefit from active transport including bikeshops, tourism (Beeton 2003; Beierle 2011; PTNY 2010; Tourism Vermont 2007; Grabow, Hahn and Whited 2010), retail activity (Hass-Klau 1993), construction (Garrett-Peltier 2010), and real estate development that highlights livability (LAB 2009).

Improved walking and cycling conditions can increase local property values and support local development (Bartholomew and Ewing 2011; Cortright 2009; Krizek et al. 2006; LGC 2001), an indication of the value that residents and customers place on these qualities, and increased economic productivity (Pivo and Fisher 2010; Buchanan 2007). Property values also tend to increase with proximity to public trails (NTTP 2005; Karadeniz 2008; Racca and Dhanju 2006). Retailers sometimes oppose non-motorized improvements, such bike lanes, based on the assumption that motorists are better customers than pedestrians and cyclists, but this is often untrue (Clifton, et al. 2012 and 2013; Fleming, Turner and Tarjomi 2013; Rowe 2013; Stantec 2011; Sztabinski 2009; TA 2006). Bicycle parking is space efficient and so generates about five times as much spending per square meter as car parking (Lee and March 2010).

Although automobile and fuel production are major domestic industries, a large portion of these products are imported. Since they are capital intensive with relatively little labor input, overall national employment and business activity increase as consumers shift expenditures from vehicles and fuel to other consumer goods, as indicated in Figure 11. As a result, reducing vehicle and fuel spending tends to support economic development. Because non-motorized facility construction is relatively labor intensive it tends to create more employment and regional business activity than other capital projects. For example, analysis by Garrett-Peltier (2010) found that a $1 million spent on bike lanes directly creates 11.0 to 14.4 jobs, compared with approximately 7.0 jobs created by the same expenditure on roadway projects.

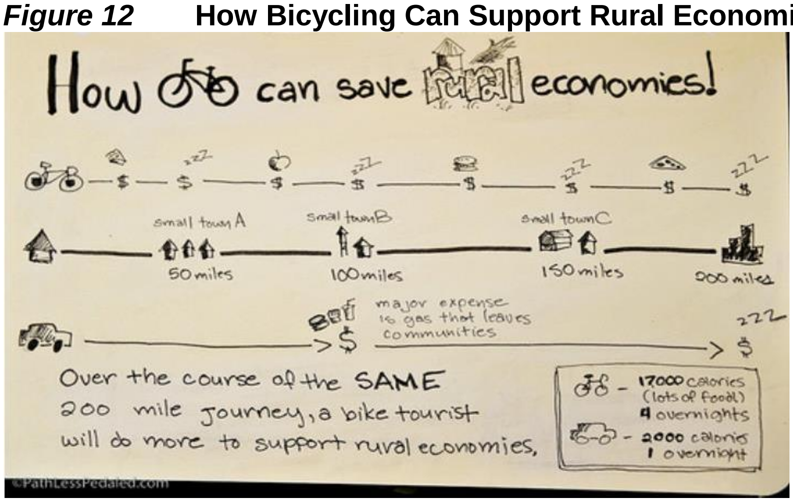
Figure 11 **Employment Impacts per $1 Million Expenditures** (Chmelynski 2008)



Fuel and vehicle expenditures produce fewer domestic jobs than most other consumer expenditures, and far less than spending on public transit.

Active mode tourism tends to provide greater economic benefits per mile of travel than other forms of tourism (Figure 12).

Figure 12 **How Bicycling Can Support Rural Economies** (Roca and Crawford 2013)



Active transport tourists tend to purchase more local goods per mile traveled than motorized tourists, which tends to be particularly beneficial to rural economies.

Some of these impacts are economic transfers, in which one group benefits at another's expense, so their analysis depends on perspective and scale. For example, improvements in one commercial center may attract customers from other commercial centers without increasing total regional economic activity. However, some impacts are true efficiency gains: resource savings that increase overall economic productivity.

Evaluation methods: Active transport economic impacts depend on specific conditions. In many situations, non-motorized improvements can provide significant economic development benefits, in addition to the other benefits described in this report. The following factors tend to maximize active mode economic development benefits:

- Where demand for active travel is high (including latent demand).
- Where non-motorized improvements are integrated with complementary strategies, such as public transit improvements, efficient pricing, and smart growth land use policies, which increase overall transport system efficiency, reduce congestion and parking costs, and reduce consumer expenditures on vehicles and fuel.
- Where active mode improvements respond to local business needs, such as creating more attractive commercial centers and supporting bicycle tourism, or expanding the pool of lower-wage employees.

Table 11 indicates methods that can be used to evaluate these impacts, and ways that non-motorized improvements can maximize economic development benefits.

Table 11 **Economic Impact Analysis** (Litman 2011)

Economic Impact	Evaluation Methods	Maximizing Benefits
Transport efficiency –transport cost savings, such as reduced congestion, facility costs, and accident damages.	Measure cost savings, as described in this report, and estimate the degree these savings benefit producers (commuters, businesses and governments).	Integrate active mode improvements with complementary strategies such as public transit improvements, efficient pricing, and smart growth land use policies.
Labor productivity – improved worker access to education and employment opportunities.	Degree that improved affordable modes improve access to education and employment.	Improvements targeting disadvantaged workers in areas where industries require large numbers of lower-wage employees. Improve other affordable modes, particularly public transit.
Land use efficiency – impacts on development patterns, and their effects on accessibility and sprawl-related costs.	Analyze land use impacts (changes in density, mix, connectivity, etc.), and resulting costs or savings to businesses and governments.	Integrate active mode improvements with smart growth land use policies.
Consumer expenditure impacts – impacts on consumer expenditures, particularly on vehicles and fuel.	Estimate vehicle ownership and travel changes, and resulting consumer expenditure changes. Use Input/Output analysis to quantify economic impacts.	Non-motorized improvements help reduce motor vehicle costs. Integrate with support strategies such as public transit improvements, efficient pricing, and smart growth land use policies.
Support for specific industries – retail centers, bikeshops, adventure tourism, etc.	Identify ways that active mode improvements help support local and regional industries.	Non-motorized improvements implemented in response to local business needs.

Active transportation planning decisions can affect economic development in various ways. Evaluation should consider, and if possible quantify, all of these impact categories. Non-motorized planning can be designed to maximize economic development benefits.

Active Mode Versus Automobile Access – Economic Development Impacts
Planning decisions sometimes involve tradeoffs between non-motorized and automobile access:

- Streetscaping and road diets often reduce general traffic lanes to provide bike lanes and wider sidewalks.
- Traffic calming and speed control programs reduce motor vehicle traffic speeds, in part to increase active travel safety and comfort.
- Some bike lanes and sidewalk widening require eliminating automobile parking lanes.

Local merchants sometimes fear they will lose business if automobile access and parking is reduced. This is not necessarily true. In many cases, improving access by alternative modes and streetscaping supports local economic development overall.

During the 1970s several North American cities had negative experiences with pedestrianized city center streets; they became unattractive to customers and business activity declined. However, appropriate pedestrian improvements can increase retail area attractiveness, particularly in urban commercial districts and resort areas ("Streetscaping," VTPI 2009). A study of ten London commercial districts found street design improvements typically increase residential and commercial property values about 5%, reflecting the value people place on an attractive street environment and resulting increases in local commercial activity (CABE 2007). Clifton, et al (2012 and 2013) found that shoppers who arrive walking, cycling or public transport tend to spend less per trip but make more trips per month and so spend more in total than automobile shoppers. In a survey of urban retail business owners, Drennen (2003) found that 65% consider a local traffic calming program to provide overall economic benefits and support program expansion, compared with 4% that consider it overall negative. Conversion of San Francisco's Central Freeway into pedestrian- and bicycle-friendly Octavia Boulevard significantly increased local commercial activity and property values (CNU 2009).

In some cases, total roadway capacity increases after general traffic lanes are converted to bus or bike paths due to a combination of smoother traffic flow after a road diet, and a significant increase in bicycle travel (NYDOT 2010). Because bicycle parking is space efficient it generates about five times as much spending per square meter as automobile parking (Lee and March 2010). In urban areas, a significant portion of retail customers arrive by walking and cycling (TA 2010). A study of customers to urban retail businesses in Toronto, Canada found (Sztabinski 2009):

- About 90% of patrons arrive by walking, cycling or public transit.
- Patrons arriving by foot and bicycle visit the most often and spend the most money per month.
- Patrons would prefer a bike lane to widened sidewalks at a ratio of almost four to one.
- Even during peak periods no more than 80% of metered parking spaces on the street are occupied.
- The reduction in on-street parking supply from a bike lane or widened sidewalk could be accommodated in the area's off-street municipal parking lots.

Negative impacts can often be addressed. Improved parking management can often off-set a loss of parking spaces, for example, by indicating where additional automobile parking is available nearby, and by encouraging local commuters and customers to arrive by alternative modes.

This indicates that in many situations, walking and cycling improvements are cost effective investments that support local economic development, particularly if implemented in conjunction with complementary transport and land use improvements.

Costs

Various costs associated with non-motorized transportation are discussed below. For more information see Bushell, et al. (2013).

Facility Costs

Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners, and the General Public (Bushell, et al. 2013), *Bicyclepedia* (www.bicyclinginfo.org/bikecost) and the report, *Guidelines for Analysis of Investments in Bicycle Facilities* (Krizek, et al. 2006), provide information on the costs of facilities such as paths, bike lanes, intersection improvements and bicycle parking. The table below summarizes some of these costs, although more specific cost data should be used when available. Dutch cities typically spend €10 to €25 annually per capita on cycling facilities, which is considered high but increases cycling activity (Fietsberaad 2008).

Table 12 **Typical Facility Costs** (FDOT 2003; Zegeer, et al 2002; Krizek, et al. 2006)

Measure	Typical Costs (2000 U.S. Dollars)
Bike lanes	$10,000-50,000 per mile to modify existing roadway (no new construction).
Bicycle parking	$50-500 per bicycle for racks and lockers
Center medians	$150-200 per linear foot
Curb bulbs	$10,000-20,000 per bulb
Marked crosswalk	$100-300 for painted crosswalks, and $3,000 for patterned concrete.
Path (5-foot asphalt)	$30-40 per linear foot
Path (12-foot concrete)	$80-120 per linear foot
Pedestrian refuge island	$6,000-9,000, depending on materials and conditions.
Sidewalks (5-foot width)	$20-50 per linear foot
Speed humps	$2,000 per hump
Traffic signals	$15,000-60,000 for a new signal
Traffic signs	$75-100 per sign.
Traffic circles	$4,000 for landscaped circle on asphalt street and $6,000 on concrete street.

This table summarizes examples of active transport facility costs. Of course, costs may differ significantly from these values depending on specific conditions.

Vehicle Traffic Impacts

Some non-motorized improvements can cause vehicle traffic delays. For example, traffic calming and speed reductions, converting traffic lanes to bike lanes or wider sidewalks, and more pedestrians and bicyclists crossing roadways, can reduce vehicle travel speeds. Similarly, converting parking lanes to bike lanes or wider sidewalks can reduce the ease of finding a parking space.

Evaluation methods: These costs can be estimated using the methods used to calculate other congestion delays, as described earlier in this report. These costs may be partly offset by direct benefits to motorists (traffic calming and speed reductions tend to reduce automobile accident risk), and indirect benefits if walking and cycling improvements cause mode shifts from driving to alternative modes, which reduces vehicle traffic and parking congestion.

Equipment and Fuel Costs

Walking and cycling may require extra equipment and fuel. Functional shoes typically cost $100 per pair and last about 1,000 miles (about a year of normal use), or 10¢ per walk-mile, although marginal costs are often small since consumers often replace shoes before they wear out. A $500 bicycle ridden 3,000 annual miles needs about $100 annual maintenance and lasts 10 years, which averages about 5¢ per mile cycled. Walking and cycling require food for fuel, which is more costly than gasoline per calorie, but the amounts are generally small (a 150 pound person burns 80 calories per mile walked, about the energy in a slice of bread, and half that when cycling), and most people enjoy eating and consume too many calories, in which case increased energy consumption is a benefit rather than a cost.

Evaluation methods: Walking and cycling equipment and fuel costs can be estimated based on typical shoe, bicycle and food costs. Since many people have underused shoes and bicycles the incremental costs of increased walking and cycling are often small. Since this analysis is not standardized, it is important to specify assumptions.

User Travel Time Costs

Travel time is one of the largest transportation costs, and since walking and cycling tend to be slower than motorized modes, they are sometimes considered inefficient and costly. However, this is not necessarily true. Measured door-to-door, active travel is often time competitive for short trips: for walking up to a half-mile, which represents about 14% of total personal trips, and for cycling up to three miles, which represents about half of total trips (Dill and Gliebe 2008; Litman 2010). Transport planning that improves pedestrian and cycling connectivity, and land use planning that creates more compact, mixed development increases the portion of trips for which active modes are time-competitive.

Travel time unit costs (cents per minute or dollars per hours) vary significantly depending on conditions and preferences (“Travel Time Costs,” Litman 2009; Mackie, et al. 2003). Under favorable conditions walking and cycling time has low or negative costs; users considered time spent on this activity a benefit rather than a cost, because it is enjoyable and provides exercise which reduces the need to spend special time exercising, so users will choose these modes even if they take longer than driving (Björklund and Carlén 2012). Because walking and cycling are inexpensive travel modes, their *effective speed* (travel time plus time spent earning money to pay for transport) is often faster than driving (Tranter 2004). These factors are highly variable. A person may one day prefer walking and another day prefer driving. If people have high quality walk and cycling conditions they can choose the mode they consider best overall, taking into account all benefits and costs.

Evaluating Impacts: Various methods can be used to measure the value user place on their travel time (“Travel Time Costs,” Litman 2009). Travel time is generally valued at 30-50% of prevailing wages, with lower values under favorable conditions and higher values under unfavorable conditions. If people choose active modes in response to positive incentives (improved walking and cycling conditions, or financial rewards) they must be better off overall (increased consumer surplus), even if their speeds decline.

Benefit and Cost Summary

Table 13 summarizes potential active transport benefits and costs.

Table 13 **Summary of Active Transport Benefits and Costs**

Impact Category	Description
Improve NMT Conditions	*Benefits from improved walking and cycling conditions.*
User benefits	Increased user convenience, comfort, safety, accessibility and enjoyment
Option value	Benefits of having mobility options available in case they are ever needed
Equity objectives	Benefits to economically, socially or physically disadvantaged people
Increase NMT Activity	*Benefits from increased walking and cycling activity*
Fitness and health	Improved public fitness and health
Reduced Vehicle Travel	*Benefits from reduced motor vehicle ownership and use*
Vehicle cost savings	Consumer savings from reduced vehicle ownership and use
Avoided chauffeuring	Reduced chauffeuring responsibilities due to improved travel options
Congestion reduction	Reduced traffic congestion from automobile travel on congested roadways
Reduced barrier effect	Improved active travel conditions due to reduced traffic speeds and volumes
Roadway cost savings	Reduced roadway construction, maintenance and operating costs
Parking cost savings	Reduced parking problems and facility cost savings
Energy conservation	Economic and environmental benefits from reduced energy consumption
Pollution reductions	Economic and environmental benefits from reduced air, noise and water pollution
Land Use Impacts	*Benefits from support for strategic land use objectives*
Pavement area	Can reduce road and parking facility land requirements
Development patterns	Helps create more accessible, compact, mixed, infill development (smart growth)
Economic Development	*Benefits from increased productivity and employment*
Increased productivity	Increased economic productivity by improving accessibility and reducing costs
Labor productivity	Improved access to education and employment, particularly by disadvantaged workers.
Shifts spending	Shifts spending from vehicles and fuel to goods with more regional economic value
Support specific industries	Support specific industries such as retail and tourism
Costs	*Costs of improving active mode conditions*
Facilities and programs	Costs of building non-motorized facilities and operating special programs
Vehicle traffic impacts	Incremental delays to motor vehicle traffic or parking
Equipment	Incremental costs to users of shoes and bicycles
Travel time	Incremental increases in travel time costs due to slower modes
Accident risk	Incremental increases in accident risk

This table summarizes potential active transport benefits and costs.

Table 14 categorizes these impacts.

Table 14 **Active Transportation Benefits and Costs**

	Improved NMT Conditions	Increased NMT Transport Activity	Reduced Automobile Travel	More Compact Communities
Potential Benefits	• Improved user convenience and comfort • Improved accessibility for non-drivers, which supports equity objectives • Option value • Supports related industries (e.g., retail and tourism) • Increased security	• User enjoyment • Improved public fitness and health • Increased community cohesion (positive interactions among neighbors due to more people walking on local streets) which tends to increase local security	• Reduced traffic congestion • Road and parking facility cost savings • Consumer savings • Reduced chauffeuring burdens • Increased traffic safety • Energy conservation • Pollution reductions • Economic development	• Improved accessibility, particularly for non-drivers • Transport cost savings • Reduced sprawl costs • Openspace preservation • More livable communities • Higher property values • Improved security
Potential Costs	• Facility costs • Lower traffic speeds	• Equipment costs (shoes, bikes, etc.) • Increased crash risk	• Slower travel	• Increases in some development costs

Active transport can have various benefits and costs.

Not all active transport improvements have all these impacts, but most have many. Various factors can affect the magnitude of these impacts:

- The demand for walking and cycling activity, including latent demand (additional walking and cycling trips that people would make with improved non-motorized conditions).
- The magnitude of change, such as the degree that walking and cycling conditions improve.
- The degree that impacts affect physically, economically or socially disadvantaged people, and therefore affect social equity objectives, such as providing basic mobility for non-drivers or improve accessibility for people with disabilities and low incomes.
- The amount that physical activity and fitness increase among sedentary people.
- Changes in motor vehicle travel, and therefore impacts on congestion, road and parking facility costs, consumer costs, accidents, energy consumption, and pollution emissions.
- The impacts on land use development patterns, and the value that a community places on more compact, mixed, accessible development.
- The degree that a particular project integrates with other complementary strategies. For example, active transport improvements tend to be particularly beneficial if implemented with public transit improvements, efficient transportation pricing (such as more efficient road, parking, insurance and fuel pricing), and smart growth land use policies.

Table 15 illustrates a matrix that can be used to summarize the impacts and benefits of a particular NMT policy or project. For example, to evaluate sidewalk improvements, indicate how much it improves walking and cycling conditions and who benefits; how much it will increase NMT activity; how much it reduces automobile travel; and how much it will change land use patterns.

Table 15 **Active Transportation Evaluation Framework**

	NMT Conditions	NMT Activity	Automobile Travel	Land Use
	Is walking and cycling easier or safer?	*Does walking or cycling activity increase?*	*Does automobile travel decline?*	*Does it strategic planning objectives?*
Describe impact				
How much				
Who is affected				

This table can help summarize the impacts and benefits provided by a particular policy or project.

The following tables indicate various types of impacts (benefits and costs) that can result from active transport improvements, and provides default values for many of these impacts, measured in mils per passenger-mile (one-thousandth of a dollar, measured $0.000). These are based on values described in this report, and from *Transportation Cost and Benefit Analysis* (Litman 2009). Where possible, these default values should be adjusted to reflect specific conditions.

Improved Active Travel Conditions

Table 16 summarizes direct benefits that result from walking and cycling improvements. These values are multiplied times the number of person-miles of travel on the improved facility. These are measured in "mils" (a thousandth of a dollar) per passenger-mile.

Table 16 **Improving Walking and Cycling Conditions** (Per Person-Mile)

Impact Category	Urban Peak	Urban Off-Peak	Rural	Overall Average	Comments
User benefits	$0.250	$0.250	$0.250	$0.250	The greater the improvement, the greater this value.
Option value	$.035	$.035	$.035	$.035	Half of *diversity value*.
Equity objectives	$.035	$.035	$.035	$.035	Half of *diversity value*. Higher if a project significantly benefits disadvantaged people.

This table summarizes the estimated value of improved walking and cycling conditions.

Increased Active Travel Activity

Table 17 summarizes typical benefit values, measured in cents per mile of travel of increased walking and cycling activity. Higher values may be justified if an unusually large number of users would otherwise be sedentary.

Table 17 **Increased Walking and Cycling Activity** (Per Passenger Mile)

Impact Category	Urban Peak	Urban Off-Peak	Rural	Overall Average	Comments
Fitness and health – walking	$0.500	$0.500	$0.500	$0.500	Benefits are larger if pedestrian facilities attract at-risk users.
Fitness and health – cycling	$0.200	$0.200	$0.200	$0.200	Benefits are larger if cycling facilities attract at-risk users.

This table summarizes the estimated fitness and health value of increased walking and cycling activity. Impacts are measured in "mils" (a thousandth of a dollar) per passenger-mile.

Reduced Automobile Travel

Table 18 summarizes typical benefit values, in cents per reduced motor vehicle-mile, including automobile travel shifted to active modes, and any additional vehicle travel reductions that result if improved walking and cycling conditions helps create more compact and mixed land use development.

Table 18 **Typical Values – Reduced Motor Vehicle Travel**

Impact Category	Urban Peak	Urban Off-Peak	Rural	Overall Average	Comments
Vehicle cost savings	$0.250	$0.225	$0.20	$0.225	This reflects vehicle operating cost savings. Larger savings result if some households can reduce vehicle ownership costs.
Avoided chauffeuring driver's time	$0.700	$0.600	$0.500	$0.580	Based on $9.00 per hour driver's time value.
Congestion reduction	$0.200	$0.050	$0.010	$0.060	
Reduced barrier effect	$0.010	$0.010	$0.010	$0.010	
Roadway cost savings	$0.050	$0.050	$0.030	$0.042	
Parking cost savings	$0.600	$0.400	$0.200	$0.360	Parking costs are particularly high for commuting and lower for errands which require less parking per trip.
Energy conservation	$0.030	$0.030	$0.030	$0.030	
Pollution reductions	$0.100	$0.050	$0.010	$0.044	

This table summarizes the estimated benefits of reduced motor vehicle travel.

Land Use Impacts

Table 19 summarizes various benefits to communities if increased walking and cycling, and associated reductions in automobile ownership and motor vehicle traffic, help create more compact, mixed land use development, which reduces sprawl-related costs.

Table 19 **More Walkable and Bikeable Community**

Impact Category	Urban Peak	Urban Off-Peak	Rural	Total	Comments
Reduced pavement	$0.010	$0.005	$0.001	$0.002	Specific studies should be used when possible.
Increased accessibility	$0.080	$0.060	$0.030	$0.051	Specific studies should be used when possible.

This table summarizes various benefits if walking and cycling improvements reduce impervious surface area and encourage more compact, mixed land use development patterns.

Active Transport Costs

Table 20 summarizes typical costs of improving non-motorized conditions and increasing active travel.

Table 20 **Typical Values – Walking and Cycling Costs**

Impact Category	Urban Peak	Urban Off-Peak	Rural	Total	Comments
Facilities and programs					Highly variable.
Vehicle traffic impacts					Highly variable.
Equipment	$0.080	$0.070	$0.060		Depends on assumption, such as whether food consumption is a benefit or cost.
Travel time					Highly variable depending on conditions and user preferences.
Accident risk					

This table summarizes potential active transport benefits and costs.

Evaluating Specific Active Mode Improvements

This section describes examples of active transport project evaluations.

Pedestrian Facility Improvements (Sidewalks, Paths and Crosswalks)

Pedestrian improvements tend to benefit existing and new users, increase walking activity, and reduce driving. Pedestrians may comfortably share roadspace with motor vehicles where traffic speeds and volumes are very low (less than 12 miles per hour and fewer than 30 vehicles during peak hour, sometimes called *naked streets*), elsewhere, sidewalks, paths and crosswalks are important, particularly for vulnerable pedestrians such as children and people with disabilities. Increased walking tends to improve public fitness and health. Since physically and economically disadvantaged people often depend on walking, pedestrian improvements tend to provide option and equity value.

Pedestrian facilities tend to have network effects so benefits increase as the network expands. A short, isolated length of sidewalk may provide minimal benefit, while a link that connects two otherwise isolated sidewalk networks, or provides a shortcut (such as connecting two cul de sacs) can provide large benefits. Pedestrian improvements can have leverage effects: increases in walking cause proportionately larger reductions in vehicle travel. For example, Guo and Gandavarapu (2010) estimate that completing the sidewalk network in a typical U.S. town would increase average per capita active travel 16% (from 0.6 to 0.7 miles per day) and reduce automobile travel 5% (from 22.0 to 20.9 vehicle-miles), or about 10 miles of reduced VMT for each mile of increased walking.

Sidewalks usually increase adjacent property values by improving access (Peffer 2009; PBIC 2009), but this reflects only a portion of total benefits since non-residents also benefit from improved access and reduced driving, so total benefits are likely to be much greater than property value changes indicate (Clark and Davies 2009).

Factors affecting pedestrian facility improvement benefits

Magnitude of improvement

- Whether it significantly improves pedestrian conditions where walking is otherwise difficult.

Demand

- Number of potential users, including youths, people with disabilities or low incomes, seniors, dog owners, and people who want to walk for exercise.
- Connects important destinations such as schools, businesses, public transit stops, and parks.

Supports special planning objectives

- If located in a commercial or resort area where walkability supports economic development.
- Whether it includes universal design to improve mobility for people with disabilities.
- If it increases physical activity by otherwise sedentary people.

Network and synergetic effects

- Whether it connects to a large pedestrian network (other sidewalks and paths).
- Whether part of an integrated program to improve alternative modes and support smart growth.

Bicycle Facility Improvement (Paths, Bike Lanes and Parking Facilities)

Bicycle improvements are similar to pedestrian improvements, although with a more limited range of users. Such enhancements benefit existing and new users, can increase cycling activity, and reduce driving. Although many cyclists can comfortably share road space with motor vehicles, particularly if traffic speeds and volumes are moderate and traffic lanes are sufficiently wide and smooth, many people are reluctant to cycle without special facilities. Increased bicycling tends to improve public fitness and health. Since some physically and economically disadvantaged people depend on cycling, bicycle facility improvements can provide option and equity value.

Bicycle facilities tend to have network effects so benefits increase as the network expands. A short, isolated length of bikepath may provide minimal benefit, while a link that connects two otherwise isolated cycling networks, or provides a shortcut (such as connecting two cul de sacs) can provide large benefits.

Factors affecting bicycle network benefits

Magnitude of improvement
- Whether located on or parallel to a busy roadway where cycling is otherwise difficult.
- If a missing link that connects sections of the cycling network.

Demand
- Number of potential users, including children and young adults, people with lower incomes, and people who want to bicycle for exercise.
- Connects important destinations such as schools, shops, public transit stops and parks.

Supports special planning objectives
- If in a commercial or resort area where access and recreation support economic development.
- If many residents are sedentary and would benefit from increased physical activity.

Network and synergetic effects
- Connects to a large cycling network.
- Is part of an integrated program of to improve alternative modes and support smart growth.

Active Transport Education and Encouragement Programs

Education and encouragement programs help overcome barriers to walking and cycling (ignorance, social stigma, a habit of driving), increase use of these modes, and reduce motor vehicle travel. Such programs tend to have synergistic effects with facility improvements. On the other hand, education and encouragement programs can fail or increase risk if walking and cycling conditions are poor.

Factors affecting education and encouragement program benefits

Magnitude of improvement

- Program quality. Whether it responds to local conditions and preferences, and so helps overcome barriers such as ignorance, social stigma, and a habit of driving.
- Whether it addresses specific problems, such as high rates of cycling traffic violations.
- Community support. Whether it attracts support from sports and recreation, school, public health, transportation, business, neighborhood and environmental organizations.

Demand

- Number of people who are likely to increase their walking and cycling activity.
- The degree that participants reduce their driving.

Supports special planning objectives

- Whether located in an area, such as a city or resort community, where reductions in automobile travel can provide large benefits (such as reduced traffic congestion and parking problems).
- The program targets people who are sedentary and overweight, and so benefit significantly from more active transport.

Network and synergetic effects

- Whether part of an integrated program to improve and encourage active transport.
- Whether it helps build broad community support for active transportation.

Public Bike Systems

Public Bike Systems (PBS, also called *Bike Sharing* and *Community Bike Programs*) provide convenient rental bicycles intended for short (less than 5 kilometer), utilitarian urban trips. A typical Public Bike System consists of a fleet of bicycles, a network of automated stations where bikes are stored, and bike redistribution and maintenance programs. Bikes may be rented at one station and returned to another. Use is free or inexpensive for short periods (typically first 30 minutes). This allows urban residents and visitors to bicycle without needing to purchase, store and maintain a bike.

Public bikes tend to benefit users directly, by providing convenient and affordable transport and recreation. They can provide additional benefits by increasing cycling activity and substitute for automobile travel (either alone or in conjunction with public transit).

Factors affecting Public Bike System benefits

Magnitude of improvement
- The convenience of the service, including the number and location of stations, the ease of use, and the quality of bikes.

Demand
- Number of people who are likely to use the services.
- The degree that Public Bike users increase their cycling and reduce their driving.

Supports special planning objectives
- Whether located in an area, such as a city or resort community, where reductions in automobile travel can provide large benefits.

Network and synergetic effects
- Whether the system is integrated with public transit services.
- Whether part of an integrated program to improve and encourage active transport.

Calculating Optimum Investments

Transportation economic analysis compares the incremental benefits and costs of different policies and programs. This section shows examples of evaluation applied to active transport (Litman 2001; Sælensminde 2004; MacMillen, Givoni and Banister 2010). The following formula can be used to determine the maximum investment justified for policies or programs that shift travel from automobile to active modes.

Optimal Investment/Year = (Benefits/Trip x Modal Shift)/Year

Example 1: Pedestrian Facility

Table 21 shows the estimated monetized benefits to society of 10,000 miles shifted from driving to active travel under urban off-peak conditions. A new public path might cause such an annual shift (e.g., 46 trips shifted daily). Using a 7% discount rate over 20 years, this represents a present value of about $100,000. This indicates the capital investment that could be justified for such a facility. Total benefits are probably much greater than estimated because some potentially large impacts are not monetized in this analysis (health and enjoyment, community livability and cohesion, etc.), so greater investments may be justified. This analysis assumes a 1:1 mode substitution rate, that is, each non-motorized mile substitutes for one motor vehicle mile.

Table 21 **Benefits of 1,000 Miles Shifted To Active Transport**

Benefits	Per Mile	Total
Congestion Reduction	$0.02	$200
Roadway Cost Savings	$0.05	$500
Vehicle Cost Savings	$0.20	$2,000
Parking Costs (assuming 1-mile average trip length)	$1.00	$10,000
Air Pollution Reduction	$0.05	$500
Noise Pollution Reduction	$0.03	$300
Energy Conservation	$0.04	$400
Traffic Safety Benefits	$0.04	$400
Total	*$1.43*	*$14,300*

This table indicates monetized benefits of 1,000 miles shifted from motorized to active travel under urban off-peak conditions. Since many benefits are not monetized, total benefits are probably larger.

A higher substitution rate would provide greater benefits. Applying the 1:7 substitution rate indicated earlier in this report (each non-motorized mile substitutes for seven motor vehicle miles), would mean that benefits average about $10 per trip and $100,000 per year. These larger benefits are likely to occur if a active mode facility is part of an overall program to create a more walkable community, which might also include changing development practices (e.g., locating more shops and schools within walking distance of homes and employment sites), roadway design, traffic management and parking management, as well as active travel encouragement programs.

Example 2: Cycling Program

Table 22 shows the funding level justified for a cycling program per percentage point shift it causes from driving to cycling in an urban community with 20,000 commute trips and 35,000 non-commute trips each day. In this case up to $280,000 could be spent for each percent of commute trips, and $365,365 for each percentage point of non-commute trips shifted from driving to active travel. Annual investments of up to $3.2 million could be justified for a bicycle improvement and encouragement program that causes a 5-point shift from driving to cycling, and more taking into account additional, unmonetized benefits. Applying the 1:7 substitution rate would mean that benefits exceed $39 per commute trip and $20 per non-commute trip. These larger benefits are likely to occur if the cycling program is part of a comprehensive mobility management program that improves travel options and encourages reduced automobile travel.

Table 22 **Maximum Funding Per 1-Point Shift from Driving to Cycling**

	Commute Trips	Non-Commute Trips	Totals
Trips per day	20,000	35,000	55,000
Days per year	250	365	
Travel Condition	Urban-Peak	Urban Off-Peak	
Benefits per trip	$5.60	$2.86	
Calculation	20,000 x 250 x $5.60 x .01	35,000 x 365 x $2.86 x .01	
Totals	*$280,000*	*$365,365*	*$645,365*

This table shows the estimated annual benefits from each one-point shift from automobile to bicycle travel, considering only monetized benefits. Total benefits are probably much higher.

Example 3: Active Mode Component of Commute Trip Reduction Program

Table 23 shows the monetized benefits from a commute trip reduction program that convinces 100 employees to shift from driving to non-motorized commuting, if they have average daily round-trip travel distances of 5 miles, $5.00 per day parking costs, and 240 annual work days. This program provides $210,000 in monetized benefits, plus additional benefits from improved health and enjoyment, and other unmonetized benefits. This indicates the level of program funding that could be justified. As described above, benefits are larger if the increased active travel leverages additional reductions in motorized travel, for example, if some households reduce their automobile ownership.

Table 23 **Commute Trip Reduction Program Benefits**

Benefits	Per Mile	Per Commuter	Total Daily
Congestion Reduction	$0.20	$1.00	$100
Roadway Cost Savings	$0.05	$0.25	$25
Vehicle Cost Savings	$0.25	$1.25	$125
Parking Costs		$5.00	$500
Air Pollution Reduction	$0.10	$0.50	$50
Noise Pollution Reduction	$0.05	$0.25	$25
Energy Conservation	$0.05	$0.25	$25
Traffic Safety Benefits	$0.05	$0.25	$25
Total		*$8.75*	*$875*

This table illustrates the value of shifting 100 employees from driving to active modes at a typical urban worksite.

Examples

*For more examples see **CATSIP** (www.catsip.berkeley.edu) and "Making the Case for Investment in the Walking Environment: A Review Of The Evidence" (Living Streets 2011).*

Danish Cycling Evaluation (COWI 2009)

The City of Copenhagen has developed a standard cost-benefit analysis (CBA) methodology for evaluating cycle policies and projects, and applied that model in two case studies. Table 24 summarizes methods used to evaluate cycling project impacts on travel activity (the amount of cycling and automobile travel).

Table 24 **Assessing Effects of Cycle Initiatives**

Effect For Economic CBA	Methodology To Quantify Travel Effects	Data Requirement
Vehicle operating costs	Change in vehicle kilometre by mode, i.e. for different motorized vehicles, public transportation and bicycles.	Traffic counts and/or modelling.
Time costs	Change in transport time by transport mode.	Traffic counts and/or modelling.
Accident costs	Change in the number of accidents with and without bicycles involved.	Accident registrations, traffic counts and/or modelling.
Pollution and externalities	Change in vehicle kilometres for each mode of transportation.	Traffic counts and/or modelling.
Recreational value	Change in cycle kilometres and cyclists' statements.	Interviews and traffic counts and/or modelling.
Health benefits	Change in cycle kilometres.	Traffic counts and/or modelling.
Safety	Change in the number of accidents, cyclist statements and change in cycle kilometres.	Accident registrations, interviews and traffic counts and/or modelling
Discomfort	Change in cycle kilometres.	Traffic counts and/or modelling.
Branding value	Not a traffic effect.	-
Value for urban open spaces	Not a traffic effect.	-
System benefits	Change in cycle kilometres.	Traffic counts and/or modelling.

This table summarizes specific ways to assess the travel impacts of cycling projects.

Table 25 summarizes unit cost values used in the economic analysis. The unit costs for cars are from the Ministry of Transportation's official unit cost catalogue (Transportøkonomiske Enhedspriser). The external values for cars are reported for gasoline cars under urban off-peak conditions. In total, cycling is estimated to have net costs (costs minus health benefits) of 0.60 Danish Kroner per kilometer. Health benefits include reduced medical and disability costs valued at 1.11 Danish Kronor (DKK) to users and 2.91 DKK to society, plus 2.59 DKK worth of increased longevity. Car travel is estimated to have net costs (costs minus duties, which are large because Denmark has very high fuel taxes) of 3.74 Danish Kroner per kilometer. This would be even higher under urban-peak conditions due to higher congestion costs.

Table 25 **Average Costs Per Kilometre For Cycling (2008 Danish Kroner)**

	Cycling (16 km/h)			For Reference: Car (50 km/h) in city			
	Internal	External	Total	Internal	External	Duties	Total
Time costs (non-work)	5.00	0	5.00	1.60	0	0	1.60
Vehicle operating costs	0.33	0	0	2.20	0	-1.18	2.20
Prolonged life	-2.66	0.06	-2.59	0	0	0	0
Health	-1.11	-1.80	-2.91	0	0	0	0
Accidents	0.25	0.54	0.78	0	0.22		0.22
Perceived safety	+ (?)		+ (?)	?	?	?	?
Discomfort	?	0	?	?	?	0	?
Branding/tourism	0	-0.02	-0.02	?	?	0	?
Air pollution	0	0	0	0	0.03	0	0.03
Climate changes	0	0	0	0	0.04	0	0.04
Noise	0	0	0	0	0.36	0	0.36
Road deterioration	0	0	0	0	0.01	0	0.01
Traffic congestion	0	0	0	0	0.46	0	0.46
Total	*1.81*	*-1.22*	*0.60*	*3.80*	*1.13*	*-1.18*	*3.74*

This table summarizes unit cost values used for economic evaluation of cycling projects.

In 2006 the City of Copenhagen opened a 200 metre long pedestrian and cyclist bridge, Bryggebroen, across the harbour of Copenhagen from Kalvebod Brygge at Zealand to Islands Brygge on Amager. The bridge supplements the existing connections, which are all intended for motorized vehicles with cycle lanes along the carriageways. Surveys indicate that the bridge carried approximately 5,500 daily cyclists in 2008 and 7,200 in 2009. A CBA study performed in 2008 indicated that the Bryggebroen bridge was a cost effective investment. It provides large benefits for cyclists, primarily in the form of time savings, which are estimated to outweigh project costs. The study estimates that the bridge provides a net present value of 36 million DKK and a 7.7% annual internal rate of return. This does not include benefits for pedestrians, increased cycling comfort, or the increased cycling volumes after 2008. Sensitivity analyses show that the results are robust.

In 2006 the City of Copenhagen rebuilt the Gyldenløvsgade-Nørre Søgade-Vester Søgade intersection to improve safety. The rebuilding included a change of the design and signals in order to minimize conflicts between road users. The project is estimated to reduce three traffic injuries per year.

Cost-benefit analysis indicates that this project is a good investment. It provides large benefits for the cyclists from the reduction in accidents and for the society in the form of saved costs and higher tax revenue. The central estimate is that the project provides a net present value of 59 million DKK and a 33% annual internal rate of return. Sensitivity analyses show that the result is robust to changes in central parameters and input data.

Queensland Active Transport Benefits (SKM and PWC 2011)

A 2011 Queensland Australia government-sponsored study estimates that an average round-trip urban bicycle commute provides $14.30 in economic benefits and a pedestrian commuter provides $8.48 worth of benefits, including:

- Decongestion (20.7 cents per kilometre walked or cycled).
- Direct health benefits (up to 168.0 cents per kilometre).
- User vehicle operating cost savings (35.0 cents per kilometre).
- Road and parking infrastructure savings (6.8 cents per kilometre).
- Environment (5.9 cents per kilometre).

Table 27 **Benefits Summary** (SKM and PWC 2011)

	Central Value	Lower Bound	Upper Bound
Health - Walking	$1.68	$1.23	$2.50
Health - Cycling	$1.12	$0.82	$1.67
Decongestion	$0.207	$0.060 (Off-Peak)	$0.340 (Peak)
Vehicle operating costs	$0.350		
Injury costs - Walking	-$0.24		
Injury costs - Cycling	-$0.37		
Noise reduction	$0.0091	$0.065	$0.0117
Air quality	$0.0281	$0.0275	$0.0288
Greenhouse gas emissions	$0.0221	$0.0196	$0.0248
Infrastructure (roadway) provision	$0.052		
Parking cost savings	$0.016		

Note: Negative values imply a disutility or increased costs. (2010 Australian Dollars)

Active Transport Evaluation (MacMillen, Givoni and Banister 2010)

In a study titled, *The Role Of Walking And Cycling In Advancing Healthy And Sustainable Urban Areas*, MacMillen, Givoni and Banister (2010) estimate the costs and benefits of pedestrianizing a commercial street in Oxford, England. They estimate that this project would reduce area vehicle trips 27%, as shoppers and commuters who currently drive shift modes. Estimated costs included the project’s capital and incremental operating expenses, increased traffic crashes, and loss of 25 car parking spaces. Estimated benefits included improved public fitness, reduced traffic congestion, increased journey ambience (more enjoyable travel experience) and greenhouse gas reductions. They conclude that current project evaluation practices overlook or undervalue many active transport benefits, resulting in an underinvestment in walking and cycling improvements.

New Zealand Active Transport Monetization Program

The New Zealand Transport Agency *Economic Evaluation Manual* provides specific procedures for evaluating walking and pedestrian improvements. It applies a benefit factor of $2.70/km to new or safer pedestrian trips, and $1.45/km for new or safer cycling trips (NZTA 2010, Vol. 2, p. 8-11). Before-and-after research measures how specific types of non-motorized improvements tend to increase active travel activity (Turner, et al. 2011).

Nonmotorized Transportation Pilot Program Evaluation (FHWA 2012)

The U.S. Federal Highway Administration produced a comprehensive evaluation of its Nonmotorized Transportation Pilot Program that assessed the costs, travel impacts and benefits of these programs. It included project-level evaluation that identified impacts of individual projects, and community-wide evaluation which used travel survey data to estimate program effects on overall community travel patterns. This analysis revealed substantial increases and continual growth in nonmotorized travel activities in each of the studied corridors and intersections, with annual increases over multiple years. This found community-wide increases of 22% for walking and 49% for bicycling between 2007 and 2010. Most of these increases consisted of utilitarian, plus increased recreational and exercise activity. In addition, anecdotal project-level studies revealed slower driving speeds and safer conditions for pedestrians and bicyclists. The study estimated health and environmental benefits, including quantities of fuel savings and emission reductions.

Cycling Improvement Economic Evaluation

Foltýnová and Kohlová (2007), analyzed impacts of improved cycling infrastructure on cycling activity using a stated preferences survey to determine willingness to bicycle in response to various cycling improvements in the city of Pilsen, in the Czech Republic. Considering just direct health and air pollution reduction benefits, the cycling facility improvements are not considered cost effective.

Bicycle Improvement Benefit/Cost Analysis (Gotschi 2011)

This study assessed how Portland, Oregon’s bicycling investments compare with its estimated benefits. Bicycling activity is estimated using past trends, future mode share goals, and a traffic demand model. This analysis indicates that by 2040, $138 to $605 million in total investments will provide $388 to $594 million in estimated healthcare benefits, $7 to $12 billion in reduced deaths, and $143 to $218 million in fuel savings. The benefit-cost ratios are positive, and very large when reduced deaths are included.

Grabow, et al. (2011) estimated the value of improved health from reduced local air pollution emissions and improved public fitness if 50% of short trips were made by bicycle during summer months in typical Midwestern U.S. communities. Across the study region of approximately 31.3 million people, mortality is projected to decline by approximately 1,100 annual deaths, providing benefits estimated to exceed $7 billion/year.

Valuing Bicycling in Wisconsin (Grabow, Hahn and Whited 2010)

The study, *Valuing Bicycling’s Economic and Health Impacts in Wisconsin* estimated the economic value of bicycling in the state of Wisconsin, including economic activity from bicycle manufacturing and sales ($593 million), tourism and recreational value ($924 million), health benefits of increased physical activity ($320 million) and pollution emission reductions ($90 million). Total estimated benefits average about $360 per resident. The study also investigated factors that affect cycling demand.

Neighborhood Design and Health

The study project, *Neighbourhood Design, Travel, and Health* (Frank, et al. 2010), describes various factors that affect walkability, methods for measuring those factors, and the impacts of neighborhood walkability on per capita automobile travel, physical activity and fitness in the Vancouver, BC metropolitan region. The results indicate that:

- Adults living in the 25% most walkable neighborhoods walk, bike and take transit 2-3 times more, and drive approximately 58% less than those in more auto-oriented areas.
- Residents in the most walkable areas, with good street connectivity and land use mix, were half as likely to be overweight than those in the least walkable neighborhoods.
- Living in a neighbourhood with at least one grocery store was associated with nearly 1.5 times likelihood of getting sufficient physical activity, compared to areas without grocery stores. Each additional grocery store within a 1-kilometer distance from an individual's residence was associated with an 11% reduction in the likelihood of being overweight.
- The most walkable neighborhoods have the least ozone pollution, but the most nitric oxide pollution. Some neighborhoods have relatively high walkability and low pollution.

Recommendations for Comprehensive Evaluation

As this report discusses, conventional economic evaluation tends to undervalue active transport. Most communities that invest significantly in active travel, such as Davis, California and Eugene, Oregon, do so without formal benefit/cost analysis; policy makers intuitively realized that active transport can provide much greater benefits than conventional planning indicates (Buehler and Handy 2008). Now that these networks are mature, residents of these cities enjoy substantial benefits, including consumer cost savings, parking cost savings, accident reductions, improved public health, reduced pollution, and stronger local economies. More comprehensive economic evaluation may help other communities recognize these benefits and therefore overcome the political and institutional barriers to improving active transport.

Below are guidelines for comprehensive active transport evaluation.

- Recognize the many roles that walking and cycling can play in an efficient transport system, including basic and affordable mobility, access to motorized travel, exercise, enjoyment and tourism.
- Use comprehensive travel surveys that count all active travel, including non-commute trips, active links of automobile and public transit trips, and recreational walking and cycling activity.
- Consider total active travel demand, including factors expected to increase future demands such as aging population, rising fuel prices, increased urbanization, and rising health and environmental concerns, and latent demand and therefore the increased walking and cycling activity that would result from improved walking and cycling conditions.
- Consider network and synergistic effects. Evaluate active mode improvements as an integrated program that includes facility improvements, traffic calming, encouragement programs and demand management strategies, rather than evaluating each project or program individually.
- Consider all categories of benefits from improved and increased active transport, including improved mobility for non-drivers, consumer savings, user enjoyment, health benefits, congestion reduction, road and parking cost savings, energy conservation, emission reductions, increased economic development, and support for efficient land use development. Do not limit analysis to just the benefits traditionally considered in motorized transport project evaluation.
- Consider active transport's leverage effects on automobile travel – each additional mile of walking and cycling tends to reduce 5-10 miles of automobile travel. This significantly increases estimated benefits.
- Consider all funding sources. Walking and cycling programs should receive substantial funding from both transportation and recreational funding sources because active transport provides both transport and recreational benefits.

Criticisms

The following criticisms are sometimes raised against claims of non-motorized benefit analysis.

Inferior Good – Declining Demand

People sometimes argue that active transportation is an *inferior good*, that is, as people become wealthier they shift from non-motorized to motorized transport, so investments in active mode facilities is wasteful and efforts to encourage active travel is either futile or harmful to consumers. Although it is true that as people shift from poverty to a mid-level income they tend to shift from non-motorized to motorized travel, further increases in wealth do not necessarily reduce walking and cycling. Many higher-income cities and countries have relatively high walking and cycling mode share. Activities such as bicycle commuting and neighborhood walking appear to be popular among higher-income people, provided that conditions are favorable (good cycling facilities, walkable neighborhoods, etc.). If this is true then active transport is not an inferior good in areas with good walking and cycling conditions, so improving such conditions is efficient and responsive to consumer demands.

Slow and Inefficient

Critics sometimes argue that, since active modes are slower, they are inefficient, as discussed in the *Costs* section of this report. While it is true that walking and cycling are often slower than automobile travel, they have an important role to play in an efficient transport system. Improving walking and cycling conditions can contribute to time and money savings that increase efficiency. Walking and cycling are the most efficient modes for shorter trips, which often support motorized travel, for example, by allowing motorists to walk from vehicles to destinations, or to walk rather than drive among various destinations located close together, such as various shops in a commercial center. Improvements, such as pedestrian shortcuts and better roadway crossings improve active travel speeds. From some perspectives, such as when evaluated based on *effective speed* (total time spent in travel, including time devoted to working to pay for vehicles and fares) non-motorized travel is often more time-efficient than motorized travel overall. Improving active travel can save drivers' time by reducing traffic congestion and the need to chauffeur non-drivers. The most efficient transport system is one in which travelers have viable options, including good walking and cycling conditions, so they can choose the most efficient mode for each trip, considering all benefits and costs.

Excessive Costs and Subsidies

Some pedestrian and cycling projects and programs may have relatively high subsidy costs per mile of travel, and so seem cost-inefficient. For example, a special pedestrian signal or pedestrian bridge may costs tens or hundreds of thousands of dollars, and depending on use and how costs are allocated, the costs may average many dollars per user, which seems high compared with roadway costs per automobile passenger. However, such analysis often underestimates true automobile travel costs and subsidies (ignoring, for example, parking subsidies and total accident costs). A pedestrian signal or bridge may allow walking or cycling to replace automobile trips that impose many dollars in total costs.

Unfair To Motorists

Motorist organizations sometimes argue that motor vehicle user revenue (fuel taxes and registration fees) expenditures on pedestrian and cycling facilities is an unfair *diversion* of money that should be dedicated to roadway facilities. This reflects a horizontal equity principle that consumers should generally "get what they pay for and pay for what they get." However, such arguments only reflect half of the equation (get what they pay for) and ignore the other (pay for what you get), which would require that virtually all roadway costs be financed by user fees, which would require 50-100% increase in such fees. In addition, special walking and cycling facilities are largely needed because of the risk and pollution that motorized traffic imposes on pedestrians and cyclists, and to reduce conflicts so motorists can drive faster than would otherwise be required. To the degree that this is true, motorists have a responsibility to help finance active mode facilities.

Inefficient and Wasteful

There is sometimes criticism that demand for active travel is exaggerated by wishful thinking, and that a particular facility or program will fail to attract users and achieve benefits as claimed. This certainly could occur, but it may reflect other problems with program design rather than an overall lack of demand. For example, a sidewalk or crosswalk improvement may attract few users if it is located in an automobile-dependent location, and a walk-to-school encouragement program may fail if walking conditions are inferior. However, where an appropriate combination of physical improvements and support are implemented, impacts are often significant, and many non-motorized projects and programs have exceeded expectations.

Conclusions

Walking and cycling play unique and important roles in an efficient and equitable transport system. They provide basic mobility, affordable transport, access to motorized modes, physical fitness and enjoyment. Improving active transport conditions benefits users directly, and benefits society overall, including people who do not currently use walking and cycling facilities.

Conventional transport project evaluation methods tend to overlook and undervalue active transport. Conventional travel statistics imply that only a small portion of total travel is by active modes (typically about 5%), but this results, in part, from survey practices which overlook many short and non-motorized trips. NMT represents a relatively large portion of total trips and travel time (typically 10-20% in urban areas), and many of the trips it serves are high value, and would be costly to perform by motorized modes. More comprehensive evaluation considers additional active transport benefits, including indirect reductions in vehicle travel, and additional benefit categories.

Some benefits are relatively easy to measure. Transport economists have developed methods for monetizing (measuring in monetary units) traffic congestion, road and parking facility costs, vehicle expenses, crash risk, and pollution emissions. Some non-motorized benefits can be estimated by adapting these values, for example, by applying the same methods used to measure reductions in vehicle congestion delays to calculating the value of reduced barrier effect delay and pedestrian shortcuts. Values used to evaluate traffic deaths and injuries can be used to value the fitness and health benefits of active transport. Affordability can be quantified by indicating cost savings to lower income users. Other impacts may be more difficult to monetize, but should at least be described. These include user enjoyment, option value, support for equity objectives, more compact and accessible land use development (smart growth), economic development, improved community livability, and additional environmental benefits such as habitat preservation.

There are many ways to improve and encourage active travel. Although most communities are implementing some of these strategies, few are implementing all that are justified. Most of these strategies only affect a portion of total travel, so their impacts appear modest, so they are seldom considered the most effective way of solving a particular problem. However, they provide multiple and synergistic benefits. When all impacts are considered, many communities can justify much more support for walking and cycling.

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