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Evaluating Active Transport Benefits and Costs

Guide to Valuing Walking and Cycling Improvements and Encouragement Programs

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Abstract

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

This report updates and expands on:
Todd Litman (2004), "Quantifying the Benefits of Nonmotorized Transportation for Achieving Mobility Management Objectives," *Transportation Research Record 1441*, pp. 134-140.

Contents

Executive Summary

Active transport (also called *non-motorized transport* or *NMT*, and *human powered transport*) refers to walking, bicycling, 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 provide various indirect benefits, so even people who do not use a particular sidewalk, crosswalk, path, or bike-rack 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 many of these benefits and so tends to underinvest in active modes.

Table ES-1 **Active Transportation (AT) Benefits and Costs**

	Improved Active Travel Conditions	More Active Travel	Reduced Automobile Travel	More Compact Communities
Benefits	• Improved user convenience, comfort and safety. • Improved accessibility for non-drivers, which supports equity objectives. • Option value. • Higher property values. • Improved public realm (more attractive streets).	• User enjoyment. • Improved public fitness and health. • More local economic activity. • Increased community cohesion (positive interactions among neighbors). • More neighborhood security ("eyes on the street").	• 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, and transport cost savings. • Agglomeration efficiencies • Reduced sprawl costs. • Openspace preservation. • More livable communities. • Higher property values
Costs	• Facility costs. • Lower traffic speeds.	• Equipment costs (shoes, bikes, etc.). • Increased crash risk.	• Slower travel.	• Increases some development costs.

Active transport has 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 transportation (also called *non-motorized transport*, *NMT* and *human powered transport*) refers to walking, bicycling, and variants such as wheelchair, scooter, and handcart use. It includes both utilitarian and recreational travel, plus stationary activities such as standing or sitting on public walkways. In this report, *pedestrian*, *walker*, *bicyclist*, and *non-driver* refer to active mode users, whereas *motorist* and *driver* refer to automobile users, although most people fall into multiple categories.

Active 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 to access public transit and parked cars. Micromodes (e-bikes, e-scooters and their variants) can approximately double active travel demands and the value of active mode improvements.
- Improving active transport can achieve transport planning objectives including reduced traffic and parking congestion, energy consumption and pollution emissions, and helps create more compact "smart growth" development.
- Walking and bicycling provide affordable, basic transport. Physically, economically, and socially disadvantaged people often rely on walking and bicycling, 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 bicycling 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 those areas, and their quality can affect local business activity and property values.
- Walking and bicycling are popular recreational activities. Active travel improvements can provide enjoyment and health benefits, and supports related recreation and tourism industries.

Approximately 12% of total U.S. trips are made by active modes and their potential is much greater. Approximately a quarter of all personal trips are one mile or less, suitable for a twenty-minute walk, half of all vehicle trips are three miles or less, suitable for a twenty-minute bike ride, and most trips are less than five miles, suitable for a twenty-minute e-bike ride (Bhattacharya, Mills, and Mulally 2019; Pisoni, Christidis, and Cawood 2022). Surveys indicate that many people want to use these modes more for enjoyment, health, and affordability (NAR 2017).

Many planning decisions affect walking and bicycling conditions and therefore the amount of active travel that occurs in a community. Conventional transportation planning evaluation tends to overlook and undervalue many active transportation benefits, resulting in underinvest in these modes, which reduces overall transport system diversity and efficiency. 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 bicycling, 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 travel 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, bicycling, public transit, automobile, ridesharing, taxi and ridehailing, telework and delivery services.

Active modes play important roles in a diverse transport system. Where walking and bicycling conditions are good, typically 10-20% of local trips are by these modes. Active modes provide access to public transit; often the best way to improve and encourage public transit travel is to improve local walking and bicycling 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 to 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 active travel 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 bicycling 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 active mode access to a bus stop may significantly increase ridership, but in another location has much smaller impacts.

Active Transport Demand and Modeling

Transport demand refers to the amount and type of travel people will choose in specific conditions. Surveys indicate growing consumer demand for active travel. For example, the National Association of Realtor's 2017 *National Community Preference Survey* found that 80% of respondents enjoy walking, more than other travel modes; most households prefer living in walkable and bikeable neighborhoods over automobile-dependent sprawl; and walkable community residents are also more satisfied with their quality of life (NAR 2018). Various demographic, geographic and economic factors affect active travel demands (Table 1).

Table 1 **Active Transport Demand Factors** (Dill and Gliebe 2008; Pratt, et al. 2012)

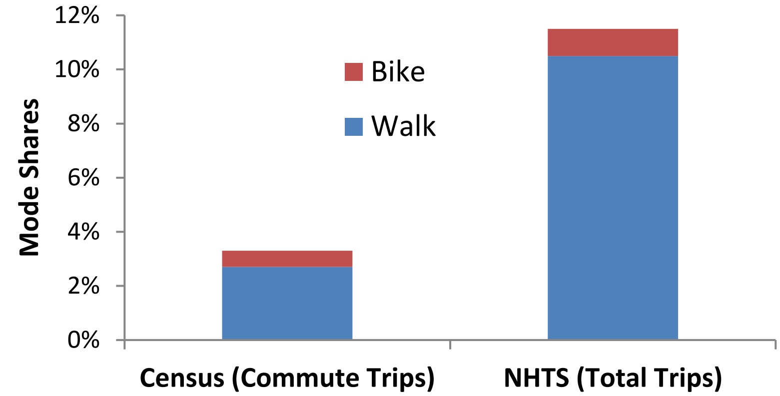
Factors	Impacts on Active Travel
Age	Young people and some seniors have high walking and bicycling rates.
Physical Ability	Some people with impairments rely on walking and bicycling, and may require universal design features such as ramps for walkers and wheelchairs.
Income and Education	Many lower-income 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 bicycling for transportation.
Travel Costs	Active travel tends to increase with driving costs (parking fees, fuel taxes, road tolls, etc.)
Facilities	Walking and cycling increase where there are good facilities (sidewalks, crosswalks, etc.)
Road Conditions	Walking and bicycling tend to increase in areas with lower traffic speeds.
Trip Length	Walking and cycling are most common for shorter (less than 2-mile) trips.
Land Use	Active mode shares increase with development density and mix.
Promotion	Walking and bicycling activity may be increased with promotional campaigns.
Public Support	Bicycling rates tend to increase where communities consider it socially acceptable.

Many factors can affect active travel demand.

Active travel is measured using travel surveys and traffic counts (Kuzmyak, et al. 2014; FHWA 2012; Nordback, Sellinger and Phillips 2017; Piatkowski and Marshall 2018; Stefánsdóttir, et al. 2024; Streetlight 2025; UTRAC 2022; Wang and Renne 2023). According to the 2017 U.S. *National Household Travel Survey*, 10.5% of personal trips are by walking and 1.0% by bicycling. Between 2001 and 2017 the portion of respondents who biked during the previous week increased from 7% to 12% and the portion that walked increased from 65% to 73%, indicating growing demand (NHTS 2017 and 2020). Del Rosario, Laffan and Pettit (2024) estimate that 43% of Sydney, Australia car commuters have a 30-minute walking/public transit option.

Conventional statistics often undercount active travel because most travel surveys undercount shorter (within *traffic analysis zones*), off-peak and non-work trips; travel by children; and recreational travel (ABW 2018; Buehler and Pucher 2023; Sullivan and O'Fallon 2010). 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 trips between parked vehicles and destinations are ignored, even if they involve several blocks of walking along public streets. More comprehensive surveys indicate that active travel is much more common than conventional surveys indicate (Forsyth, Krizek and Agrawal 2010; Negm, et al. 2025; Pike 2011), so if statistics indicate that 5% of trips are by active modes, the actual amount is probably 10-20%. Delclòs-Alió, et al. (2021) found that in large Latin American cities, 30% of trips are entirely by walking and residents actually walk 73% to 217% more than conventional surveys indicate.

Figure 1 **Active Mode Shares** (2017 NHTS; 2013-2017 US Census)

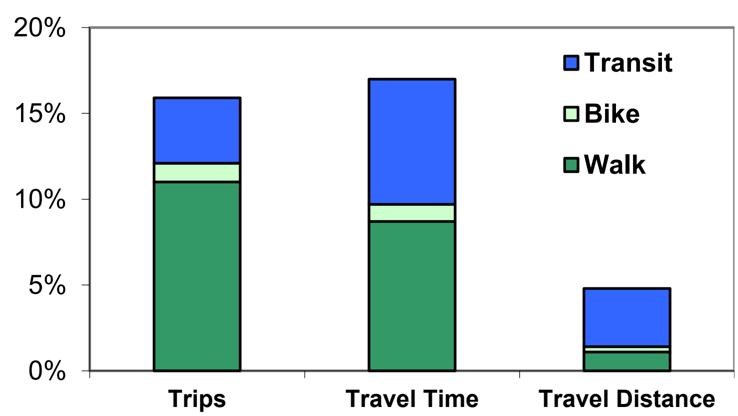


Census data indicate that only 3.3% of commute trips are by active modes, but that survey ignores youths' and recreational travel, and walking and bicycling links of motor vehicle trips.

More comprehensive surveys indicate that about 12% of total trips are by active modes, with much higher rates in urban areas and by lower-income travellers.

Although active modes serve a small portion of total travel *distance* they represent a much larger portion of *trips* and *travel time* as shown below. As a result, improving walking and bicycling conditions can provide significant time savings and user benefits.

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

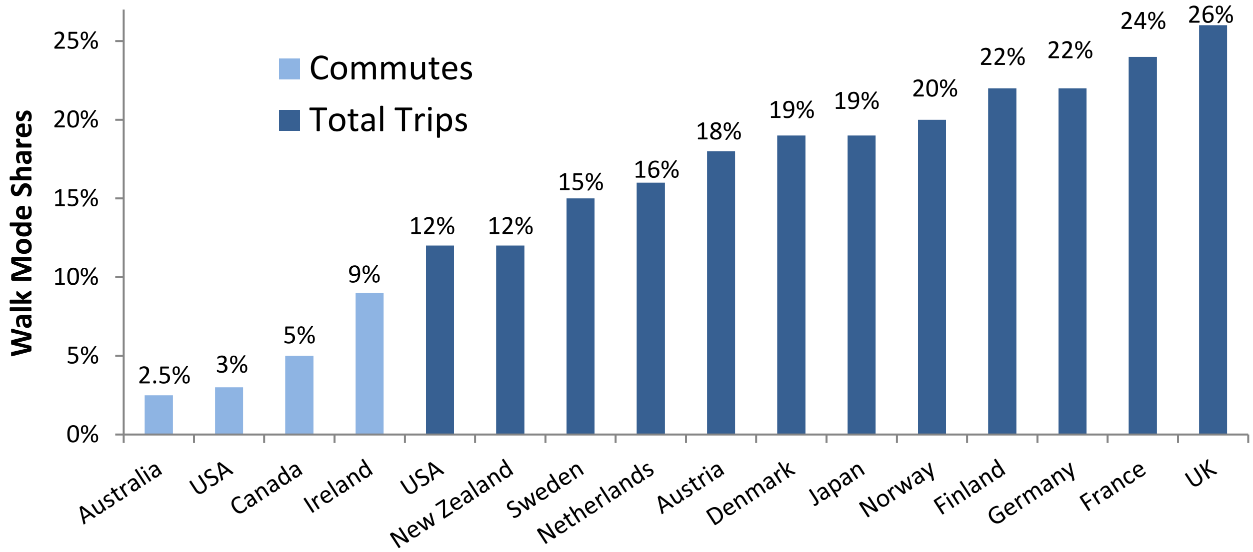


Active modes serve a small portion of travel distance but a larger share of trips and travel time.

As a result, improving active and micromode travel conditions and speeds can provide significant time savings and benefits.

The study, "Overview of Walking Rates, Walking Safety, and Government Policies to Encourage More and Safer Walking in Europe and North America," (Buehler and Pucher 2023) found that walking mode shares are lower for commutes than for total trips, and are lower in North America and New Zealand than in peer countries, as illustrated below.

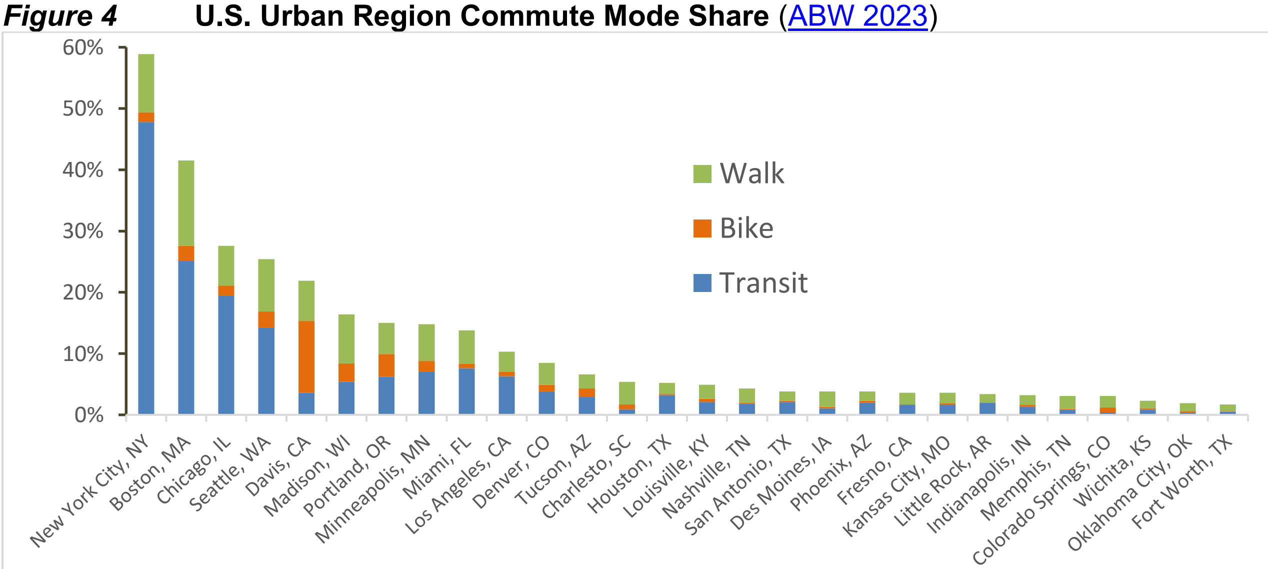
Figure 3 **Walking Mode Shares** (Buehler and Pucher 2023)



Walking mode shares are lower in Australia and North America than most peer countries.

Active mode shares vary widely among US cities, as illustrated below. These differences do not reflect geography or climate. For example, Portland and Seattle are wet and hilly, and Scandinavian countries have cold, wet climates, but have high active mode share due to supportive policies (ABW 2018). Large variations also occur between neighborhoods (Frank, et al. 2010; Litman 2008). Multi-modal neighborhoods often have ten times as much active travel as automobile-oriented neighborhoods. 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).

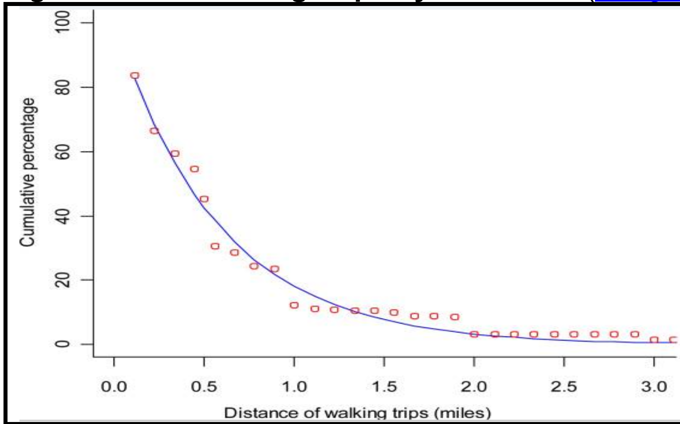
Figure 4 **U.S. Urban Region Commute Mode Share** (ABW 2023)



Cities vary widely in non-auto mode shares, due largely to transportation and land use planning decisions.

The study, *The Multimodal Majority?* found that during a typical week about 7% of Americans rely entirely on non-auto modes, about half use non-auto modes at least three times a week, and 25% use a non-auto mode seven or more times each week (Buehler and Hamre 2015). Blumenberg, Brown and Schouten (2020) find that about 20% of U.S. households are car-deficit, meaning they have more drivers than vehicles, and often rely on non-auto modes.

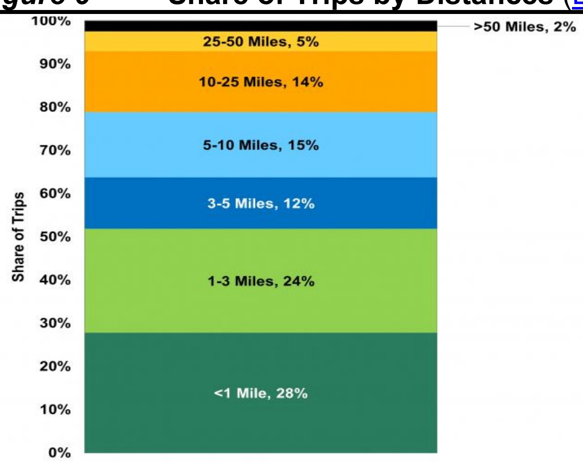
Figure 5 **Walking Trips by Distances** ([Yang and Diez-Roux 2012](#))



The 2009 National Household Travel Survey indicates that mean and median walking distances were 0.7 and 0.5 miles, respectively. About 65% of walking trips were more than 0.25 miles, and about 18% were more than 1 mile. The distances and durations of walking for recreation were substantially longer than those for other purposes. People with lower household income walked longer distances for work but shorter distances for recreation.

Most U.S. vehicle trips are short enough that they could be made by active and micro modes in less than 20 minutes (considered the maximum duration for most common trips), as illustrated below, and are sometimes faster than driving.

Figure 6 **Share of Trips by Distances** ([BTS 2021](#))

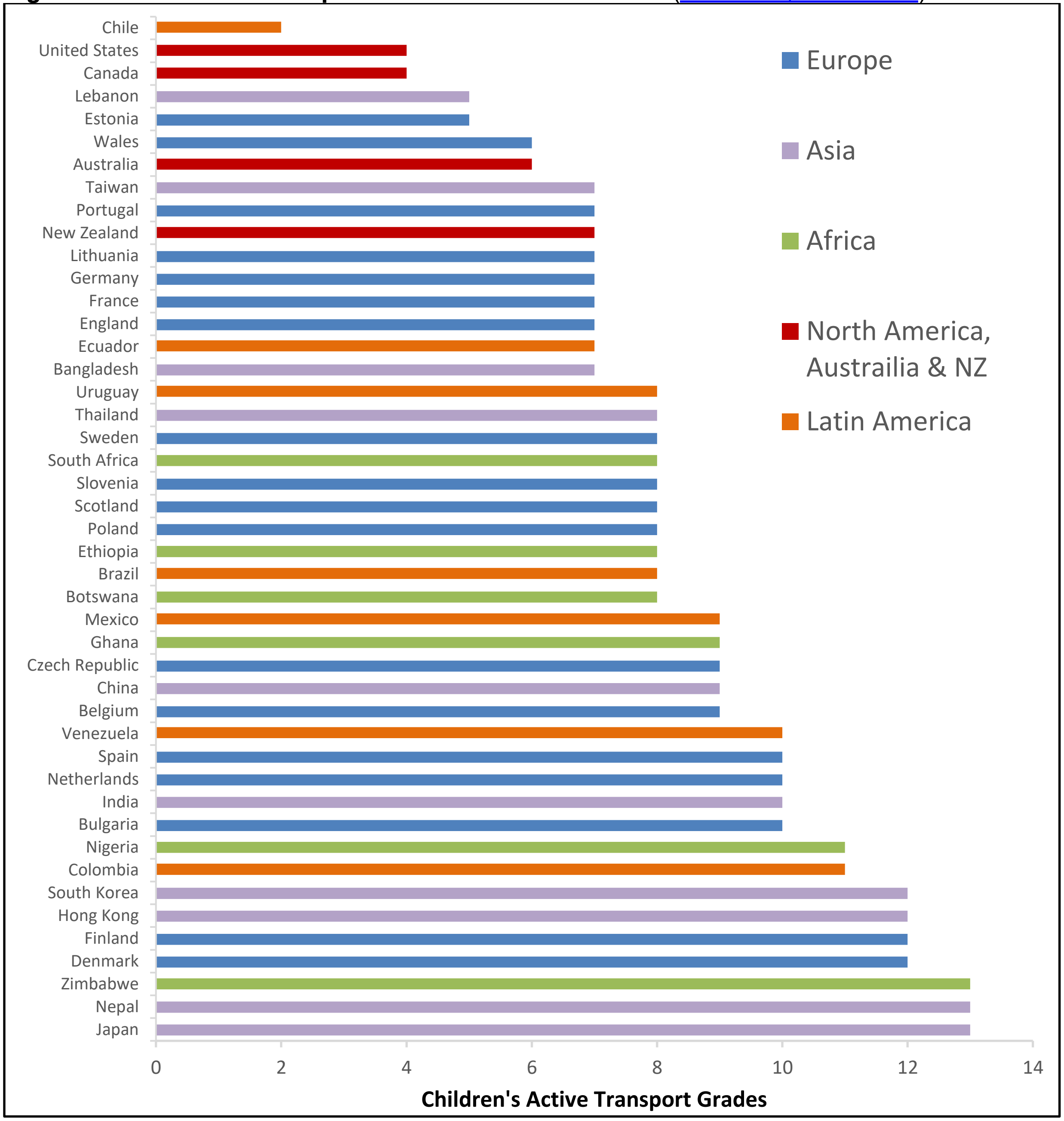


According to the Bureau of Transportation Statistics (BTS) in 2021, 28% of all trips were less than one mile (suitable for walking), 52% were 3 miles or less (suitable for bicycling) and 64% are less than 5 miles (suitable for e-bikes).

This indicates that a majority of current automobile trips are within walking and bicycling distances, and many could shift to active or micromodes if given suitable support and incentives.

Healthy Kids Global Alliance study, “Profiles of Active Transportation among Children and Adolescents,” rated countries based on the portion of children and youth who use active modes for utilitarian travel (e.g., to school, park, mall, friend’s house), as illustrated in the following graph. The US, Canada, Australia and New Zealand have low ratings, indicating that many youths lack independent mobility and exercise. Currently only 11% of US elementary students and only 26% of Canadian students walk or bike to school, a lower rate than in most other countries and far less than the 41% recorded in 1969 (Kontou 2020).

Figure 7 **Active Transport Grades for 45 Countries** (González, et al. 2020)



This graph compares the portion of children and youths who use active mode for utilitarian travel (e.g., school, park, mall, friend's house). The US, Canada, Australia and New Zealand have low ratings indicating that children in those countries have limited independent mobility and physical exercise.

Active travel tends to increase with improved services and facilities. For example, Guo and Gandavarapu (2010) estimate that expanding sidewalk networks in typical American communities increases per capita walking and reduces. A New York study found that bikeshare trips increased 18% in the 12 months following the installation of protected bike lanes, much more than provided by painted bike lanes and 'sharrows' (Moran, Salman, Yabe 2026).

Modelling Active Travel

Transport modeling refers to methods used to predict how travel activity is affected by specific transport system changes (Clifton, et al. 2015; Kuzmyak, et al. 2014; Pratt, et al. 2012; Rudolph 2017). Conventional models can be improved to better incorporate active travel (Lewis, Grande and Robinson 2020), and specialized models can predict how transport and land use changes affect active travel (McDonald, et al. 2007; NZTA 2019; Molino, et al. 2012; UTRAC 2022).

The report, *Quantifying Reductions in Vehicle Miles Traveled from New Bike Paths, Lanes, and Cycle Tracks* (Volker, et al. 2019), Handy, Tal and Boarnet (2014), and the *Active Link Mode Shift Potential Tool* (UTRAC 2022) provide guidance for predicting active mode potential (AMP) in particular situations. They indicate that under current conditions about 12% of total trips are made by walking and about 1% by bicycling, but these could be increased significantly given better facilities and conditions.

Active Travel Demands

In most communities, 20-40% of the population cannot, should not, or prefer not to drive as described in the box to the right. More than half of all U.S. trips are within a 20-minute bike ride and a quarter within a 20-minute walk (Bhattacharya, Mills and Mulally 2019). There is evidence of significant latent active travel demands; many people want to walk and bicycle more than they currently do but face obstacles (ABW 2023; Ipsos 2022; Leinberger 2012). Sidewalks, crosswalks, bikelanes and public paths improvements often significantly increase walking and bicycling activity (Buehler 2016; CPSTF 2017; FHWA 2014; Fitch-Polse and Agarwal 2025; SSTI 2024; Handy, Tal and Boarnet 2014; Yang, et al. 2021). Current demographic and economic trends (aging population, rising travel costs, urbanization, and increased health and environmental concerns) are increasing active mode demands and the benefits of accommodating this demand (Buehler 2016; Litman 2006).

Types of Non-Drivers (Litman 2022)

- Youths, 12-24 years olds (10-25% of population).
- Seniors who do not or should not drive (5-15%).
- Adults unable to drive due to disability (3-5%).
- Low-income households burdened by vehicle costs (15-30%).
- People impaired or distracted by alcohol, drugs or devices.
- Visitors who lack vehicle or licenses.
- People who want to walk or bike for enjoyment and health.

Lower-stress bicycle facilities, such as protected bicycle lanes, can achieve much larger bicycle ridership growth than higher-stress facilities such as standard bicycle lanes and shared-lane markings. A New York study found that bikeshare trips increased 18% in the 12 months following the installation of protected bike lanes, much more than provided by painted bike lanes and ‘sharrows’ (Moran, Salman, Yabe 2026). Ferenchak and Marshall (2025) found that bicycle commuting is about four times higher on roads with standard bikelanes and about eight times higher on roads with protected bikeways. Another U.S. study found that a 10% increase in bikeway-miles increases bicycle commute mode shares 2.5%, and 4% if they are protected bicycle lanes (Yang, et al. 2021). Analyzing before-and-after counts, Matute et al. (2016) found that bike trips more than doubled after high quality bicycle facilities were completed, with a 70% automobile substitution rate (10 additional bicycle trips reduce 7 auto trips). Cities with extensive walk and bike networks, such as Davis, California; Eugene, Oregon; and Boulder, Colorado have more than 15% active commute mode shares, five times the national average, and less than 20 daily vehicle miles travelled per capita, 20% less than the national average (Buehler 2016). Dong (2020) found higher rates of utilitarian walking and bicycling in central neighborhoods than in suburbs and rural areas. Timmons, et al. (2024) point out that opposition to bikeways tends to decline after they are completed and residents experience their benefits.

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 30-40% 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, active mode improvements reduced approximately 0.25 to 0.75 daily vehicle-miles per adult, 1-4% of total vehicle travel. The Australian *TravelSmart* program, which encourages residents to use non-auto modes, typically reduces automobile trips 5% to 14%, about half resulting from shifts to active travel (TravelSmart 2005). Krizek and McGuckin (2019) used 2017 *National Household Travel Survey* data concerning *little vehicles* (LVs) travel activity. In large metro areas, three-quarters of LV trips are less than 4 km (2.5 mi), and half are shorter than 2 km (1.2 mi)—a distance often considered too far to walk. These vehicles are used proportionately more for commuting than errands, and men were more likely than women, and young people were more likely than older people to use LVs. Active travel can leverage additional vehicle travel reductions, meaning that each additional mile walked or biked reduces more than one vehicle-mile due to mechanisms described below.

Active Leverage Effects (Cairns et al. 2004; Guo and Gandavarapu 2010)
Walking and cycling improvements often leverage additional vehicle travel reductions in these ways:

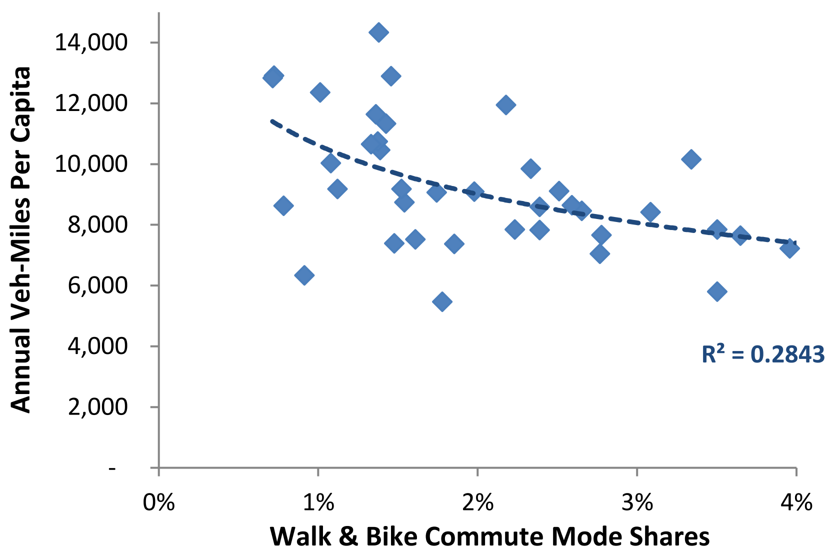
- *Shorter trips.* Shorter active trips often substitutes for longer motorized trips, such as walking or biking to local shops rather than driving to regional shopping centers.
- *Reduced chauffeuring*. Better active travel conditions can reduce the need for motorists to chauffeur non-drivers. Since those trips often generate empty backhauls, a mile walked or biked can reduce two vehicle-miles of travel.
- *Increased public transit.* Walking and bicycling improvements can support transit travel. Improving walking and bicycling access is often one of the most effective ways of increasing transit travel.
- *Vehicle ownership reductions*. Improving non-auto travel conditions allows some households to reduce their vehicle ownership. Since motor vehicles are costly to own but relatively cheap to use, once households own a vehicle they tend to use it, including some relatively low-value trips.
- *Lower traffic speeds.* One of the most effective ways of increasing active travel is to reduce urban traffic speeds. This makes walking and bicycling trips more time-competitive with driving and reduces total automobile travel.
- *Land use patterns*. Walking and bicycling improvements can help create more compact, multimodal communities with less land devoted to roads and parking, which reduces vehicle travel.
- *Social norms.* More walking and bicycling can help increase social acceptance of alternative modes.

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

This effect can be evaluated by using a *fixed travel time budget*, which recognizes that most people devote 60-80 daily minutes to travel (Ahmed and Stopher 2014). Shifts from faster to slower modes result in shorter trips, for example walkers and bicyclists choose closer destinations or forego unnecessary auto trips. Since driving is typically five to ten times faster than active modes, each mile shifted from auto to active modes generally reduces five to ten vehicle-miles as travellers maintain their total daily travel time target.

The figure below illustrates this effect. Each percentage-point increase in active mode share, indicating a few hundred more average annual walk- and bike-miles, is associated with a 5-10% reduction in vehicle-miles, indicting a five- to ten-fold leverage effect (5-10 fewer vehicle-miles for each additional active mode mile).

Figure 8 **Active Mode Shares and Per Capita VMT** (FHWA *Highway Statistics*)



This graph illustrates the relationship between active commute mode shares and per capita vehicle-miles for the 40 largest U.S. cities. Each percentage-point increase in active mode share, an additional 10-20 annual miles of walking and bicycling, is associated with a 5-10% reduction in average motor vehicle travel, 500 to 1,000 fewer annual vehicle-miles. This indicates leverage effects.

Other studies have similar results. Althoff, et al. (2025) analysed changing in walking activity after 7,447 people moved to new urban neighborhoods. They found that moving from a less walkable (25th percentile) city to a more walkable city (75th percentile) caused an average increase of 1,100 daily steps, with similar declines caused by moves from walkable to less walkable areas. These changes hold across different genders, ages and body mass index values. Guo and Gandavarapu (2010) found that installing sidewalks on all streets in a typical North American community adds 0.097 average daily walk- and bike-miles per capita and reduces 1.142 vehicle-miles, about 12 miles of reduced driving for each additional active mode mile. Wedderburn (2013) found that each additional daily transit trip by New Zealand urban residents increases average daily walking (in addition to transit access walking trips) by 0.95 trips and 1.21 kilometers, and reduces two daily car driver trips and 45 vehicle-kilometers. International data indicates that each mile of increased active travel is associated with seven reduced motor vehicle-miles (Kenworthy and Laube 2000).

Active mode demands and infrastructure needs are expanding. Many communities are seeing a proliferation of micromodes, including e-bikes, electric scooters, and automated delivery carts. E-bikes can approximately double the portion of trips suitable for light two-wheelers. More use of wheeled luggage and shopping bags, and delivery services such as Amazon and Fedex, increase the number and diversity of hand carts used on public walkways. Levinson (2023) recommends rethinking sidewalk design and performance standards to serve these emerging needs.

Micromodes

Micromodes are light electric-powered vehicles including e-bikes, e-scooters and their variants. In recent years their technology has improved and become more affordable, and they have become more common. A typical utilitarian e-bike costs from $1,000 to $5,500, and cargo style e-bikes from $2,000 to $9,000, resulting in $400 to $800 annualized costs (ownership, maintenance, battery replacement, and charging costs), which is about twice as much as a manual bicycle but an order of magnitude less than a typical automobile (Bennett, et al. 2022).

Compared with active modes they are significantly faster and can therefore travel farther and access more destinations in a given time period, can carry heavier loads including passengers (usually children) and cargo, and can climb steeper hills. As a result, they significantly increase the portion of trips that can be made by lightweight modes.

Academic studies estimate that improving bicycle and e-bike conditions could approximately triple bicycle mode shares to 17% in 2030 and up to 22% in 2050 and reduce urban vehicle emissions up to 12% (Mason, Fulton and McDonald 2015; McQueen, MacArthur, and Cherry 2020). Similarly, a major study for the New Zealand Transport Agency, *Mode Shift to Micromobility* (Ensor, Maxwell and Bruce 2021), estimated that 3-11% of all urban trips could be made by micromodes by around 2030 and increase transit ridership by up to 9% by improving access to stops and stations. University of Washington's Urban Freight Lab replaced vans with electric cargo bikes to deliver packages in a Seattle neighborhood. The study found that cargo bikes are often able to make more direct and faster trips than vans, which halved vehicle miles traveled and reduced tailpipe emissions by 30% per delivery (SCTL 2021).

Because of their potential demand and ability to replace automobile travel, Micromodes significantly increase the return on investment from active mode investments. If previous analysis justified spending 10% of transportation budgets on bicycling programs, Micromodes could justify increasing this to 20-30%, representing their mode share targets (the portion of trips that communities want to be made by these modes) and their value of their total benefits.

To achieve their potential Micromodes require various improvements and incentives:

- Subsidize Micromode purchase and recharging station networks comparable to those provided for electric cars per unit of emissions reduced (Boudway 2022).
- Protected paths and low-speed streets to make both human and electric powered bicycling very safe. A community should be willing to spend as much to accommodate a bicycle or micromode trip as an automobile trip to the same destination. Currently, most communities devote less than 10% of their infrastructure funding and road space to active modes; increasing investments in their facilities to their mode share targets would typically triple investments in these modes.
- Support development of local Microhubs to support cargobike delivery systems.
- Incentives to use smaller modes when possible. Because most vehicle costs are fixed, vehicle owners have little incentive to avoid driving. More efficient parking pricing (motorists pay directly for using parking facilities), plus distance-based vehicle insurance would give motorists more savings when they reduce their vehicle-miles. Traffic speed reductions and road space reallocation could make biking more time competitive with driving. Mobility management marketing programs can promote the user savings and benefits of shifting from automobile to active and micromodes.

Evaluating Active Travel Conditions

Below are examples of indicators for evaluating walking and bicycling conditions (Blumenberg, et al 2016; Kittelson 2023; Semler, et al. 2016; Shashank and Schuurman 2018; TRB 2022):

- *Level-of-Service* (*LOS*, also called *Service Quality*) rates performance from *A* (best) to *F* (worst). Rating systems exist for active modes (Blečić, et al. 2020; ITDP 2018). These include:
    1. *Bicycling LOS* considers bicycle paths, number of unsignalized intersections and driveways, traffic and bike lane widths, parking lanes, motor vehicle traffic volumes and speeds, portion of heavy vehicles, grades, and special conflicts such as freeway off-ramps.
    2. *Pedestrian LOS* considers sidewalk, path and crosswalk conditions, pedestrian crowding, vehicle traffic speeds and volumes, perceived separation between pedestrians and motor vehicle traffic (including barriers such as parked cars and trees), street crossing widths and density, 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.
- The *Cool Walkability Index* rates pedestrian comfort in hot climate cities (Litman 2023a).
- *BikeAble* (www.railstotrails.org/our-work/research-and-information/bikeable) is a customizable tool for evaluating community connectivity and bicycle network improvements.
- The American Association of Retired Person's *Walk Audits* (AARP 2022), and the Pedestrian and Bicycle Information Center's *Walkability* and *Bikeability Checklists* rate conditions and needs.
- The Copenhagenize Index (https://copenhagenizeindex.eu) evaluates cities based on the quality of bicycling infrastructure, traffic calming, mode shares, safety advocacy and planning.
- The *Guide to Pedestrian Analysis* provides guidance for estimating pedestrian volumes and risk exposure in a particular situation (TRB 2022).
- Guzman, Oviedo and Cantillo-Garcia (2024) recommend that walkability rating systems reflect the quality of walking conditions and proximity to services and activities for various groups.
- Before and after studies of walking and bicycling improvements that measure changes in active travel activity (Turner, et al. 2011).
- *Acceptable Walking Distance*. The table below indicates acceptable walking distances.

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.

Benefit and Cost Categories

Active transportation can have various benefits and costs (Bhattacharya, Mills and Mulally 2019; Bruntlett 2025; Ding, et al. 2024; Gössling, et al. 2019; ITDP 2022; SfQL 2024; WHO 2022). Some of these impacts depend on active travel conditions, others on active travel, reductions in automobile travel, or changes in development patterns, as summarized in Table 4.

Table 3 **Active Transportation (AT) Benefits and Costs**

	Improved AT Conditions	Increased AT Transport Activity	Reduced Automobile Travel	More Compact Communities
Benefits	• Improved user convenience, comfort and safety • Improved accessibility for non-drivers, which supports equity objectives • Option value • Higher property values • Improved public realm (more attractive streets)	• User enjoyment • Improved public fitness and health • More local economic activity • Increased community cohesion (positive interactions among neighbors) • More neighborhood 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, and transport cost savings. • Agglomeration efficiencies • Reduced sprawl costs • Openspace preservation • More livable communities • Higher property values • Increased security
Costs	• Facility costs • Lower traffic speeds	• Equipment costs (shoes, bikes, etc.) • Increased crash risk	• Slower travel	• Increases in some development costs

Active transport has various benefits and costs.

The table below summarizes factors that affect the magnitude of these impacts. Some impacts overlap. For example, many economic development benefits result from the transport and infrastructure cost savings so it is important to avoid double-counting when valuing total benefits.

Table 4 **Factors Affecting Active Transport Benefits and Costs**

Category	Factors Affecting Their Magnitude
Improved walking and bicycling 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 bicycling activity	Amount walking and bicycling 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 active transport 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 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 active mode improvements that significantly improve people's ability to enjoy recreational walking and bicycling 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 bicycling improvements affect nearby property values. For example, analysis of Walk Score (www.walkscore.com) ratings find that families and businesses willingly pay 35-45% higher prices for homes and commercial building space in the most walkable neighborhoods (Katz 2020; Rodriguez and Leinberger 2023).
- *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.

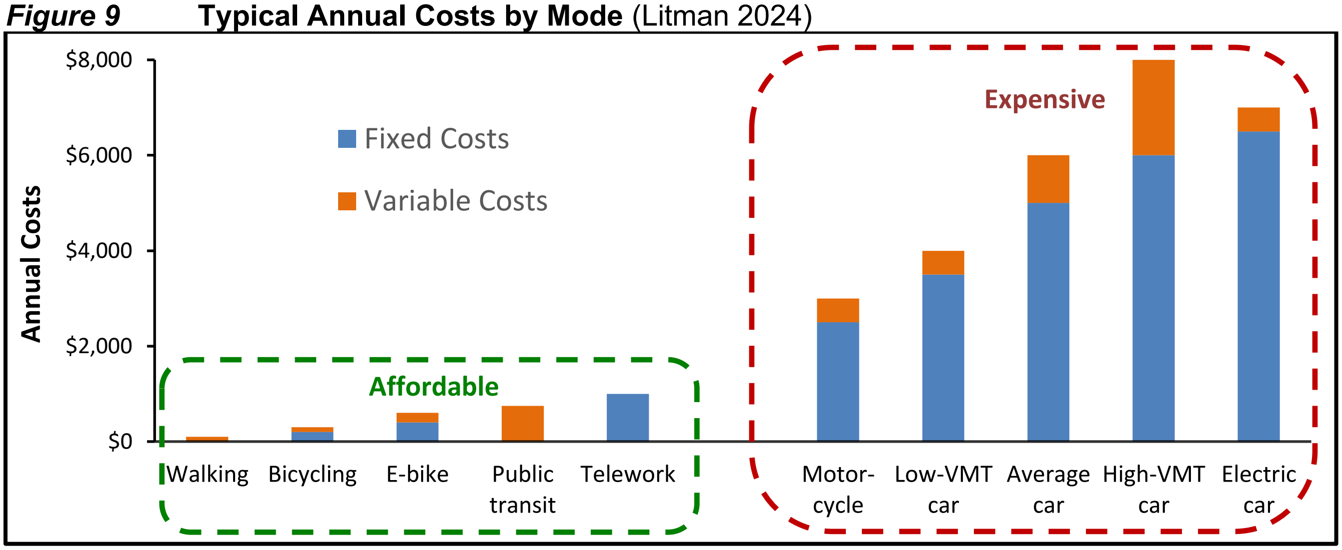
In some situations, a combination of methods should be used. For example, the total value of health benefits may include a reduction in government, business, and consumer healthcare costs; reduced worker disability costs and improved productivity; users' willingness-to-pay for reduced illness and longevity;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

User Benefits

Improving active mode conditions (better sidewalks, crosswalks, paths, bike parking, traffic speed reductions, etc.) directly benefit *existing users* (people who would walk or bicycle anyway) and *new users* (people who walk or bicycle more in response to improvements). 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 connections to other modes, such as to public transit stops, and between automobiles and destinations.
- Active transport provides basic mobility, alone and in conjunction with public transport. In a typical community, 20-40% of residents are limited in their driving ability and so depend on non-automobile modes if available. As a result, active transportation helps improve disadvantaged people's independence and economic opportunity, achieving equity goals.
- Pedestrian environments serve many functions and are a critical part of the public realm (public spaces where people naturally interact). People stand, wait, socialize, play, eat, work, and shop on sidewalks and paths, 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 travel is less stressful than driving, and contributes to mental health and happiness (Wild and Woodward 2019).
- Active modes provide enjoyment and exercise. Surveys indicate that walking and bicycling 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).

Figure 9 **Typical Annual Costs by Mode** (Litman 2024)



Walking, bicycling (including e-bikes) and public transit are more affordable than automobile travel. Most vehicle costs are fixed so vehicle owners save little from marginal reductions in annual mileage, but owning one less automobile can typically save $3,000 to $5,000.

Evaluation methods: Various methods can be used to measure active mode benefits:

- *Avoided costs* (vehicle travel and exercise cost savings). Walking and bicycling improvements reduce expenditures on motor vehicles, transit fares and 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 bicycling improvements on nearby property values). Various studies indicate that walkability improvements tend to increase local property values (Bartholomew and Ewing 2011; Katz 2020; Krizek et al. 2006; Rodriguez and Leinberger 2023).

Standen (2018) used economic modeling to evaluate the direct user benefits (welfare gains) from bicycle facility improvements that increase bicycling activity in Australia. He points out that, although walking and bicycling are often slower than driving, users who shift mode in response to facility improvements must benefit overall, reflecting lower travel time unit costs. Rodriguez and Leinberger (2023) found that families and businesses willingly pay 35-45% higher prices for homes and commercial space in the most walkable neighborhoods, reflecting the savings and benefits they provide, and the shortage of such neighborhoods relative to demand. Cortright (2009) found that a one-point Walk Score 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 Walk Score increase. Similar impacts are found in Canadian cities. Calgary, Alberta neighborhoods with the greatest home price increases were in the city’s core with higher Walk Score (Toneguzzi 2013). Buchanan (2007) found 5.2% higher residential values and 4.9% higher retail rents in more walkable London neighborhoods. Song and Knaap (2003) found that, all else being equal, house values are 15.5% higher in walkable neighborhoods. A Swedish survey bicyclists place a higher value on travel time savings and on protected bike lanes (Börjesson and Eliasson 2012).

Residential property values also tend to increase with proximity to public trails (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 bicycling are widely accepted and supported, and if residents can self-select, so people who value active travel can locate near such facilities, while people who dislike such facilities can move away.

The greater the improvement, the greater the benefit, and the more users the greater the total benefits. This benefit can be worth about $0.50 per user-mile (i.e., one person walking or bicycling one mile under improved walking and bicycling conditions) if active travel conditions improve from very poor to very good, based on evidence from hedonic pricing studies and avoided cost analysis.

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 bicycling 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 active mode 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.

Social 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. In most communities, 20-40% of the population cannot or should not drive due to disability, low incomes, or age. Walking and bicycling 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*. Walking, bicycling and public transit improvements tend to increase transport system affordability, improving mobility for lower-income users.
- *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 (ITDP 2022; ITF 2023; 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 bicycling 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 is 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 (Buehler 2016; ITF 2014; Sinnett, et al. 2011). Even small increases in physical activity can improve public health (Sallis, et al. 2004). Experts recommend that adults spend at least 150 weekly minutes (22 daily minutes) in moderate physical activity, with additional health benefits achieved through increased rigorousness and 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 bicycling are among the most practical and effective, particularly for inactive and overweight people (Bassett, et al. 2011). The U.S. Center for Disease Control's *Healthy People 2020* program includes specific objectives to increase walking and bicycling (www.healthypeople.gov). Residents of more multimodal communities exercise more and are less likely to be overweight than in automobile-oriented areas (Frank et al 2022). A major study of 429,334 UK residents found that, accounting for other demographic factors, increased neighborhood walkability is associated with reduced blood pressure and hypertension risk (Sarkar, Webster and Gallacher 2018). Using data from 11,041 high-school students in 154 U.S. communities (Slater, et al. 2013) found that those living in more walkable communities have lower odds of being overweight or obese.

Ma and Ye (2021), used data from a large survey conducted in Victoria, Australia to explore the relationships between the built environment, utilitarian bicycling, and mental wellbeing. They found that bicycling is positively associated with life satisfaction and negatively associated with psychological distress, and bikeable neighborhoods are associated with better mental health. A comprehensive review by Sinnett, et al. (2011) found significant physical and mental health benefits of improved walkability and increased walking activity. Higher levels of walking are associated with reduced obesity, diabetes, blood pressure, cardiovascular disease, and cancer, which reduces overall mortality rates. It is also linked with reductions in anxiety and depression, and improved self-worth, mood and have a positive impact on self-esteem.

A major study of 263,450 U.K. commuters by Celis-Morales, et al. (2017) found that, controlling for other factors, pedestrians and bicyclists have lower cardiovascular and cancer risk and lower all-cause mortality rates, indicating that on average cycle commuting provides net health benefits and increases longevity. Using detailed health and community design data from 8,776 Southern Ontario neighborhoods, Creatore, et al. (2016) found that overweight, obesity, and diabetes rates tend to decline significantly with neighborhood walkability.

In a study of residents in 14 cities, Sallis, et al. (2016) found that controlling for other demographic factors, net residential density, intersection density, public transport density and number of parks were significantly, positively related to physical activity. The physical activity differences between residents of the most and least activity-friendly neighbourhoods ranged from 68 to 89 min/week, which represents 45–59% of the 150 min/week recommended by guidelines. This implies that transportation and land use planning decisions can significantly affect public fitness and health.

The *Health Economic Assessment Tool* (HEAT) (WHO 2024) and the *Dynamic Modeling for Health Impact Assessment* (DYNAMO-HIA) (Mansfield and Gibson 2015) calculate monetized values of policies and projects that improve and increase walking and bicycling, including savings from avoided driving, improved public fitness and health, reduced congestion and pollution, changes in traffic crash risks and consumer welfare. The DYNAMO-HIA methodology accounts for changing population health characteristics over time, which results in significantly lower benefit estimates than the HEAT Tool, so they can be used to reflect lower- and higher-bound values.

Mulley, et al. (2013) estimate that in Australia the reduced mortality and morbidity provided by an active lifestyle provides benefits worth on average AU$1.68 per km (range $1.23–$2.50) for walking and AU$1.12 per km (range $0.82–$1.67) for bicycling.

A major ten-year study found that the overall health of residents of new housing developments improved when their daily walking increased due to better 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 bicycling, including changes in crash risk, pollution exposure, and public fitness. The study concluded that Barcelona's *Bicing* public bike rental system causes 0.03 additional annual traffic crash 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 ratio does not account for the additional health benefits from reduced accident risk and reduced air pollution exposure to other residents.

Rabl and de Nazelle (2012) estimate the health impacts of shifts from car to bicycling or walking, considering four effects: changes in physical fitness and ambient air pollution exposure to users, reduced pollution to others, and changes in accident risk. They estimate that shifting to bicycling for a 5 km one-way commute for 230 annual days provides physical activity health benefits worth 1,300 € annually and air emission reduction worth 30 €/yr. overall, and increases bicyclists' air pollution exposure costs 20 €/yr., but this depends on conditions; cyclists' pollution exposure can be reduced if they ride separated from major roadways. Paris and Amsterdam's data imply that any accident cost increase is an order of magnitude smaller than fitness health 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 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.

Active Transportation Health and Economic Impact Study (Urban Design 4 Health and AECOM 2016) evaluated the health and economic benefits of active transportation infrastructure investments for the Southern California Association of Governments (SCAG). It predicted that implementing the region's active transportation plans will provide significant health benefits, preventing 81,657 cases of hypertension, 15,985 cases of heart disease and 15,076 cases of diabetes, providing annual benefits worth $226 million in healthcare savings and $111 million in productivity gains. It will also provide significant economic benefits including increased employment and income, and increased productivity from healthier workers.

There is sometimes concern that urban pedestrians and cyclists are exposed to high levels of air pollution, particularly because they breathe deeply (Jarjour, et al. 2013). Pankow, Figliozzi and Bigazzi (2014) measured cyclists' air pollution exposure on Portland cycling routes. They conclude:

- Cyclists ventilate (breathe) two to five times more than automobile occupants.
- Pollution concentrations are 50-120% higher on urban arterials than local roads.
- Pollution exposure is generally lower on bike paths, except those in industrial areas.
- Pollution concentration is significantly lower on parallel low-volume facilities.
- Pollution exposure increased with traffic volumes and ambient temperatures.

There is also evidence that active transport provides psychological benefits. Using *British Household Panel Survey* data, Martin, Goryakin and Suhrcke (2014) found that accounting for potential confounding variables relating to work, residence, and health, overall psychological wellbeing was significantly higher for active modes commuters compared to car travel or public transport. Switching from car travel or public transport to active travel was associated with an improvement in wellbeing when compared to maintaining car travel or public transport. Negative associations were identified between time spent driving and wellbeing. Increased walking appears to reduce cognitive decline and dementia (Erickson, et al. 2010).

Evaluation methods: Some studies monetize the health benefits of improved walking and cycling (Fishman, et al. 2012; Genter, et al. 2008; Litman 2009; Boarnet, Greenwald and McMillan 2008; 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 *Health Economic Assessment Tool for Cycling and Walking* (WHO 2014) provides 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 health benefits from increased physical fitness and reduced 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. This additional physical activity is 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

Vehicle Savings
Reducing vehicle ownership and use can provide various types of savings, summarized in the table below. Short urban trips tend to have high costs due to cold starts and congestion.

Table 5 **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 refer to additional vehicle travel specifically to transport a passenger, as opposed to *ridesharing* in which a passenger rides in a vehicle that would travel regardless (Litman 2015). 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, external costs, and increasing non-drivers' independence. Surveys indicate that 5-15% of total vehicle trips are for chauffeuring; with higher rates in automobile-dependent communities and lower rates 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

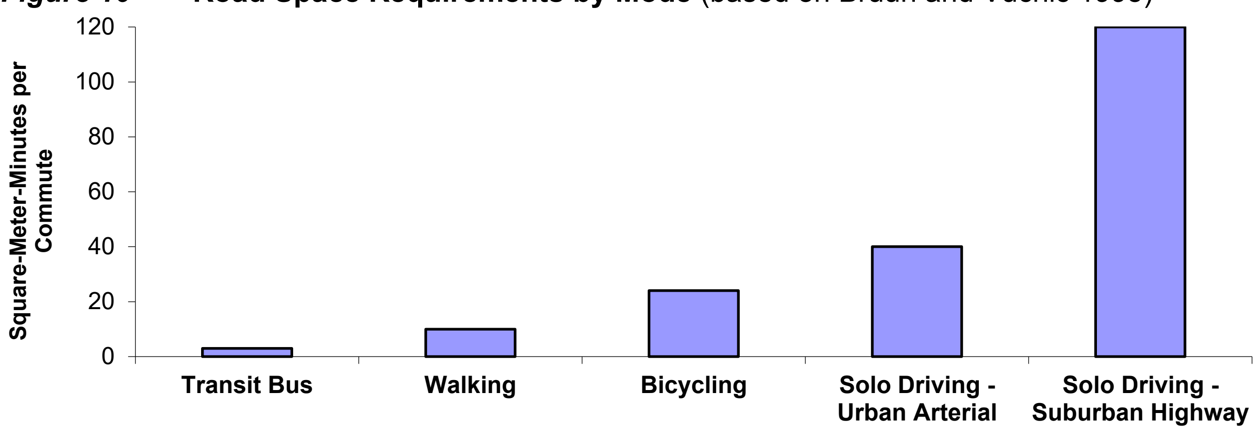
Traffic congestion costs consist of the incremental travel time, vehicle operating costs, stress and pollution emissions that a vehicle imposes on other road users ("Congestion Costs," Litman 2009). Walking and cycling conditions can affect vehicle trip generation in several ways:

- 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). Where 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 increase 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 bicycling conditions tends to reduce vehicle traffic and therefore congestion (Koska and Rudolph 2016). 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 safely travel about 15 meters apart, but at 100 KPH they require about 150 meters. Various studies calculate the space requirements of different 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, as illustrated below.

Figure 10 **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 and bicyclists can cause delays when crossing roads, or where roads lack sidewalks. Such impacts are still 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. The table below summarizes these impacts.

Table 6 **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 faster vehicles cannot easily pass can cause traffic delay.

Congestion is reduced when travelers shift from driving to bicycling under the first three conditions. Only under condition 4 does shifting fail to reduce congestion. This represents a small portion of bicycle travel because most bicyclists avoid riding in such conditions. Detailed analysis of traffic speeds on lower-volume urban roads without bicycle lanes found, the presence of a bicycle generally reduced passenger car travel speeds by 1 mph or less, which the authors considered negligible (Schaefer, Figliozzi and Unnikrishnan 2020). The *FLOW Multimodal Transport Analysis Methodology and Impact Assessment Tool* (www.h2020-flow.eu) evaluates active transport impacts on transport system performance. Case studies indicate that walking and bicycling improvements generally reduce congestion (Rudolph 2017). Traffic simulation found that adding bicycling lanes typical Australian suburb could increase average car travel times by at most 7%, which the authors consider negligible and likely to be offset by travel time savings to bicyclists (Nanayakkara, et al. 2022).

There is evidence that active travel improvements often reduce traffic congestion (Johnson and Johnson 2014; Randersen 2014). Metz (2021) fund that London bike lanes reduce congestion overall by shifting travel from automobiles to bicycles, reducing total vehicle traffic.
A major study for the Arizona Department of Transportation found less per capita congestion in older, higher density areas than in newer, lower density suburban areas due to more mixed land use (particularly more retail in residential areas) and a more connected street grid which enables more walking and bicycling and reduces automobile trips (Kuzmyak 2012).

Hourdos, et al. (2017) found that drivers on roadways with bicycle lanes were less likely to encroach into adjacent lanes, pass or queue when interacting with cyclists than on a road with no bike lanes. If bike lanes substitute for general traffic lanes, they may increase congestion, but in other cases, they 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 underestimate 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. However, 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 bicycling 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).

Hamilton and Wichman (2016) use a unique fine-grained traffic dataset to measure the Washington DC Capital Bikeshare program's impacts on congestion. They find that bikeshare stations reduce traffic congestion by 4% or more compared with congestion intensity that would otherwise occur, with the greatest reductions in the most congested areas.

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). 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 active mode users. 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 must 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, as well as 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 2019). 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 active 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

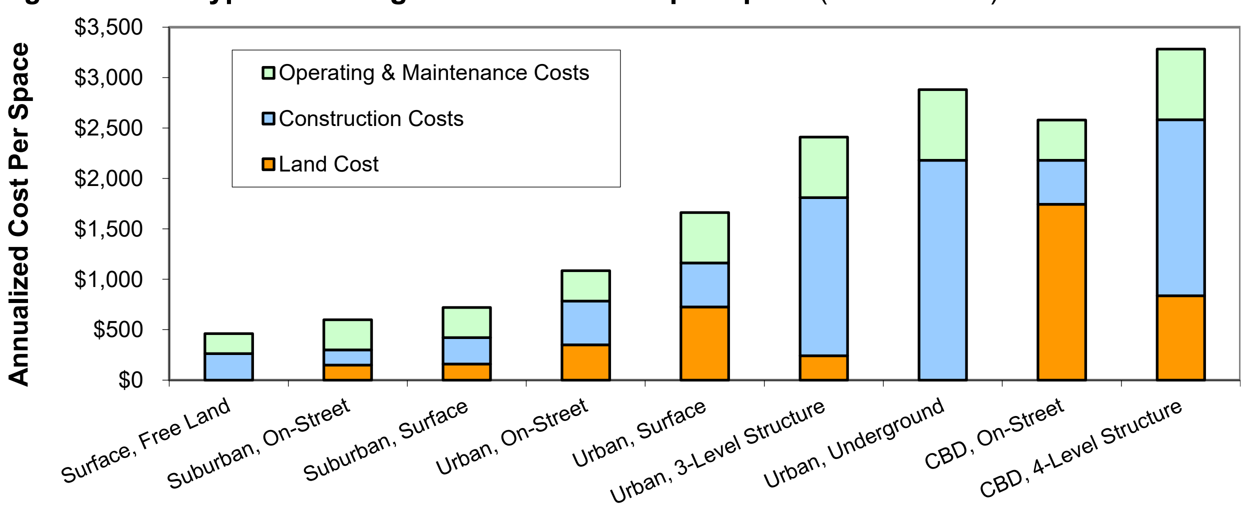
Roadway costs on average are about $550 annually per capita in the U.S., about half of which is funded through general taxes rather than user fees (FHWA 2008; Subsidy Scope 2009). In Canada, local roadway capital and operating costs are estimated to total $18.8 billion in 2000 (TC 2008, Table 3-4), which 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 requires 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) totaling $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 11 **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, vehicle trip reductions may result in unoccupied parking spaces but 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).

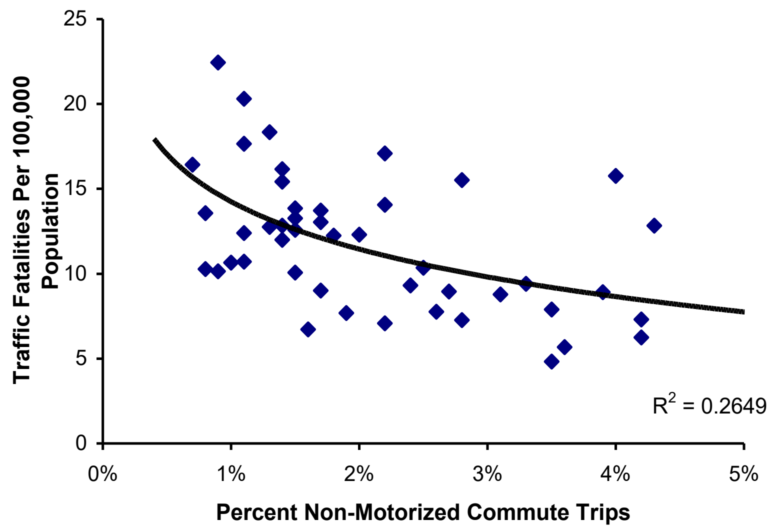
Traffic Safety Impacts

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 is compensated by vehicle insurance and therefore external to the individual traveler but internal to motorists as a group. Although walking and cycling have higher per-mile casualty rates than automobile travel, shifts from automobile to active travel tends to reduce total crash costs due to the following factors (WHO 2008):

1. Pedestrian and bicycle facility improvements (sidewalks, crosswalks, bikeways and traffic speed reductions) improve safety. For example, roads that lack sidewalks have about three times the pedestrian crash rates as those with sidewalk (Abou-Senna, Radwan and Mohamed 2022) and traffic speed reductions increase safety for all travellers.
2. 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.
3. Active travel imposes minimal risk to other road users.
4. 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.
5. 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.
6. Some walking and cycling promotion programs include education and facility improvements that reduce participants' per-mile pedestrian and bicycle crash rates.
7. 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 8 and 9, an effect called "safety in numbers" (Jacobson 2003; NHTSA 2022). Areas with high rates of walking and cycling tend to have low per capita traffic death rates (Fietsberaad 2008; ABW 2010). Overall, longevity tends to increase with increased walking and cycling activity (Cavill, et al. 2008). For example, Murphy, Levinson and Owen (2017) found that in 448 Minneapolis city intersections, pedestrians had a lower risk of being hit by a car at intersections with higher pedestrian traffic, demonstrating safety in numbers.

Figure 12 **Traffic Fatalities vs. Active Transport** (US Census 2000)

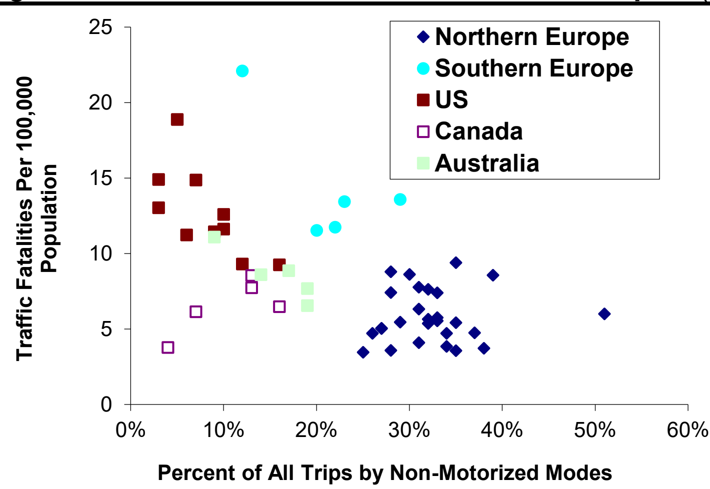


Per capita traffic fatality rates tend to decline as active travel increases. This is called "safety in numbers," (Jacobsen 2003)

Chu (2006) concluded that walking has 1.7 times the fatality rate per minute of travel than motor vehicle travel, with significant variation by time of day and age of walker, and on how risk is measured. The incremental risk for a responsible pedestrian or bicyclist 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.

Figure 13 **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 is partly due to increased street network density both supports cycling and reduces traffic speeds and therefore risk. Marshall, Ferenchak and Janson (2018) found similar results at the municipal level. Geyer, et al. (2006), and Turner, Roozenburg and Francis (2006) also find that shifts from driving to active modes by responsible adults are unlikely to increase total crashes, and per capita collisions between motorists, pedestrians and bicyclists decline as active travel 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 shifts from automobile to active travel are estimated to average 5¢ per urban peak mile, 4¢ per urban off-peak mile, and 3¢ per rural mile. These benefits are greater when combined with reductions in walking and bicycling 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.

Community Cohesions and Security (Reduced Crime Risk)

Community cohesion (also called *neighboring*, *placemaking* or *social capital*) refers to the quality of social interactions among community members as indicated by the degree that they know and care about neighbors and participate in community activities (Litman 2025). Increasing community cohesion tends to reduce crime and increase residents' sense of security.

Improving and increasing active travel tends to encourage community cohesion and reduce crime rates. For example, Gilderbloom, Riggs and Meareshttp://www.sciencedirect.com/science/article/pii/S0264275114001474 - af015 (2015) found that, accounting for other demographic and economic factors, Walk Score was significantly associated with lower murder, violent, property and total crime rates in most Louisville, Tennessee neighborhoods. Using high-resolution data to evaluate how land use factors affect Chicago neighborhood street crime (robbery and assault), Twinam (2018) found that crime rates decline with population density, and although they increase near commercial land uses, particularly liquor stores and late-hour bars, dense mixed-use areas are safer than typical residential areas. The results suggest that allowing more development density and mix tends to reduce crime risks compared with conventional policies. Also using high-resolution land use and crime data, Humphrey, et al. (2019) found that crime rates increase in commercial districts, they decline near businesses, such as cafes and convenience stores, that are open more weekly hours.

Chang and Jacobson (2017) found that, all else being equal, Los Angeles neighborhood crime rates decline with walkability, and temporary closures of medical marijuana dispensaries, due to state laws changes, and to restaurants due to health code violations, caused street crime rates to increase, and then decline again after they reopened. The authors conclude that this probably reflects "eyes upon the street" crime deterrent effects. After adjusting for socioeconomic factors such as age, employment status and income, Browning, et al. (2010) found that per capita violent crime rates decline with density in Columbus, Ohio neighborhoods, particularly in the most disadvantaged areas. Christens and Speer (2005) also found that per capita violent crime rates decline with density in the Nashville, Tennessee region.

Energy Conservation
Motor vehicle production and use consume large amounts of natural resources, particularly energy such as petroleum and coal, called *embodied energy*. 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. Active transport can provide relatively large energy savings if it substitutes 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%. In addition, as previously described, active transport tends to have leverage effects, so comprehensive active mode improvements 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), 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 cause air, noise, and water pollution which harm people, agricultural and the natural environment (Chester and Horvath 2008; TC 2008; Wolfe, et al. 2019). The impacts of some pollutants, such as noise, carbon monoxide, and particulates, are very local, so their costs depend on where emissions occur, while the impacts of others, such as ozone, methane and carbon dioxide, are regional and global, so their costs are less affected by location ("Air Pollution," Litman 2009). Walking and cycling produce minimal pollution. Users are exposed to similar air pollution levels as automobile occupants (Frank, et al. 2010).

Various methods are used to evaluate active transport emission reductions (DRISI 2016). Many underestimate actual reductions by assuming that a mile of walking or bicycling reduces just one vehicle-mile, ignoring leverage effects as discussed in the box on page 9. Guo and Gandavarapu (2010) found that installing sidewalks on all streets in a typical North American community reduces about 12 motor vehicle miles per additional mile walked or biked, and active modes tend to substitute for short trips that have high emission rates due to cold starts and congestion.

The Global High Shift Cycling Scenario estimates that dramatically increasing bicycle and e-bike use to serve all consumer demands could reduce up to 11% of urban transportation emissions. Maizlish, Rudolph and Jiang (2022) conclude that active transportation improvements that result in residents achieving physical activity targets (150 weekly minutes for physical activity) could reduce transportation emissions 24% *and* avoid 167,000 deaths and gain 2.5 million disability-adjusted life years, with $1.6 trillion monetized health benefits. In contrast, vehicle electrification that achieves the same emission reductions only reduces 1,400 deaths and gains 16,400 disability-adjusted life years, providing $13 billion health benefits. Analysis of travel activity in seven European cities found that increased walking and bicycling significantly reduces motorized travel and per capita carbon emissions (Brand, et al. 2021 and 2022). An average person who shifts from driving to bicycling one daily trip 200 days a year decreases approximately 0.5 tonnes of annual CO^2 emissions, a substantial reduction of per capita GHG emissions. The largest shifts were for business purposes, followed by social, recreational and commuting trips.

Ngo (2016) used before-and-after travel surveys conducted from 2012 to 2015 to measure the vehicle travel, emissions, health impacts of the Comox-Helmcken Greenway, a two-kilometre pedestrian and bicycle pathway in downtown Vancouver, British Columbia. The sample consisted of 207 participants divided into two groups: 135 participants living within one block of the Greenway (treatment group), and 72 participants living at least a half-kilometre away from the Greenway (control group). The results indicate statistically significant reductions of −22.9% for average daily motorized GHG emissions (before: 1.1 kg CO_2 e; after: 0.9 kg CO_2e) −23.7% for energy consumption (before: 16.0 MJ; after: 12.2 MJ).

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 other air toxics, 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). 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*. These occurs because walking, cycling and public transit require more compact and mixed development for access, and these modes are more space-efficient than automobile travel. The table below compares road and parking space requirements of various modes for a typical commute. This table 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; Appleyard 2020).

Table 7 **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 below. Most communities have objectives to encourage more compact development; redevelop urban neighborhoods, reduce impervious surface area, and preserve open-space (parks, farmland, forests, etc.). These objectives are important regardless of whether or not they are directly labelled as Smart Growth initiatives.

Table 8 **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; plus 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 bicycling 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 ("Land Use Impacts," Litman 2009).

These impacts can be difficult to evaluate because they are numerous (analyses often focus on some but overlook others), can be 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 three New Hampshire neighborhoods of varying built form, and thus varying levels of walkability were surveyed about their levels of social capital and travel behaviors. The results indicate that more walkable neighborhoods have higher levels of social capital.

Economic Opportunity and Resilience

By improving affordable access to economic opportunities, including education, employment and basic services, active transportation tends to increase *economic mobility* (the chance that children raised in a lower-income household become economically successful as adults) and *economic resilience* (ability to respond to unexpected financial stresses such as reduced incomes or new financial burdens). This is amplified for physically, economically and socially disadvantaged people (Jaffe 2016; Levy, McDade and Dumlao 2010; Sisson 2018), and non-drivers in general (Kneebone and Holmes 2015). Frederick and Gilderbloom (2018) found that lower automobile mode shares are associated with less income inequality between white and African-American households, and between men and women, and with higher earnings for white women and African-American men. Gilderbloom, Riggs and Meares (2015) and Won, Lee and Li (2017) found that neighborhoods with higher Walkscore ratings have lower foreclosure rates, indicating improved economic resilience.

Using income and travel data for more than 3.66 million Americans, Oishi, Koo and Buttrick (2018) found a statically robust positive relationship between walkability and economic mobility. Employment and income disparities between workers who could and could not drive was much smaller in more walkable cities, indicating that walkability is particularly important for lower-income workers who cannot drive. They also found that residents of more walkable neighborhoods, and people who walk more in their daily lives, felt a greater sense of belonging to their communities, which is associated with actual changes in individual social class.

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 (Boarnet, et al 2017; ECF 2018; Flusche 2012; Kornas, et al. 2016; Litman 2025b; Rohani and Lawrence 2017; Walk Boston 2011; TfQL 2024):

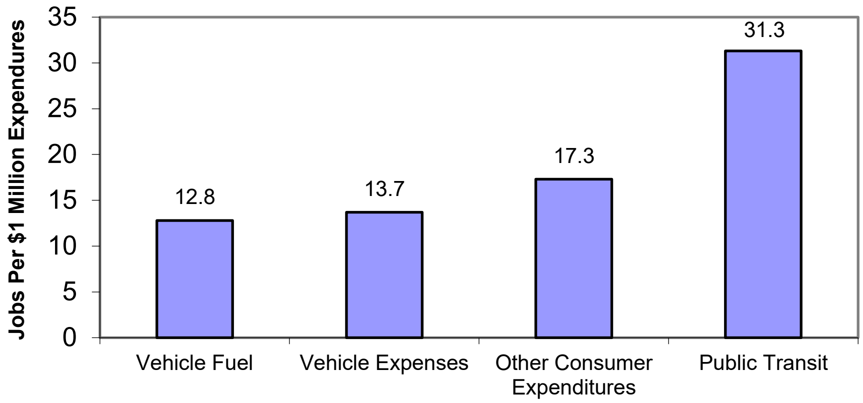
- *Transport efficiency*. Walking and cycling improvements can increase transport system efficiency by reducing traffic congestion, road and parking facility costs, and accident damages, as described previously in this report. To the degree that this reduces costs to commuters, businesses and governments, it can increase economic productivity and competitiveness.
- *Labor access.* Active travel, alone and with public transit improvements, can improve access to education and employment opportunities, particularly by non-drivers, increasing the labor pool available to businesses, which increases productivity and competitiveness.
- *Labor productivity*. Active transportation tends to increase labor productivity by increasing worker fitness and work days (Henderson, et al. 2010; Ma and Ye 2019).
- *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 (ACA 2013; Heldt and Liss 2013; Tourism Vermont 2007; Grabow, Hahn and Whited 2010; Qian, et al. 2016; Velo Quebec 2015), retail (Hass-Klau 1993; SfQL), construction (Garrett-Peltier 2010), and urban development.

A detailed literature review, *The Public Pound* (SfQL 2024), found that people who shop by active modes (walking, bicycling and their variants) spend more money per trip, shops in pedestrianised streets have higher sales per square foot, and more walkable environments create more economically productive and resilient communities, make people happier and healthier, and reduce inequalities by providing access regardless of ability and income. Improved walking and bicycling conditions tends to increase local property values and support local development (Bartholomew and Ewing 2011; Boarnet, et al 2017; Katz 2020; Krizek et al. 2006; Loh, Leinberger and Chafetz 2019), an indication of the value that residents and customers place on these qualities, increased economic productivity, and transportation cost savings (Buchanan 2007, Kornas, et al. 2016, Pivo and Fisher 2010). Loh, Leinberger and Chafetz (2019) found that walkable neighborhoods, which they labeled *WalkUPs*, have 11-198% rent premiums.

Property values also tend to increase with proximity to public trails (Karadeniz 2008; Racca and Dhanju 2006). Retailers sometimes oppose active mode improvements, such bike lanes, based on the assumption that motorists are wealthier and therefore better customers, but this is often untrue (Clifton, et al. 2013; Fleming, Turner and Tarjomi 2013; Rowe 2013; 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). Rohani and Lawrence (2017) found labor productivity increases with commercial area walkability, indicating that pedestrian improvements support economic development.

Although automobile and fuel production are major domestic industries, they are capital intensive with relatively little labor input, and many inputs are imported, so national productivity and employment tend to increase if consumers shift expenditures from vehicles and fuel to other consumer goods, as illustrated below. As a result, reducing vehicle and fuel spending tends to support economic development. Active mode facility construction 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 14 **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). A 2014 study estimated that tourists on Quebec, Canada's La Route Verte network spend an average $214 per day, 6% more than other types of tourists (Velo Quebec 2015). Heldt and Liss (2013) describe how different types of cycling tourists can affect economic activity: affluent bicycle tourists from other countries, and domestic tourists who would otherwise spend their holiday dollars elsewhere, contribute most to regional and national economic development. Such tourists tend to demand relatively high-quality cycling facilities (comfortable and safe routes and trails) and amenities (restaurants, hotels, etc.).

Some 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 areas without increasing total regional economic activity. Other impacts are resource savings that increase overall 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:

- High active travel demand.
- Active travel improvements that are integrated with complementary strategies such as public transit improvements, efficient pricing, and Smart Growth development policies, which increase overall transport system efficiency.
- Active mode improvements that respond to local needs, such as creating more attractive commercial centers, or expanding worker pools or supporting tourism.

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

Table 9 **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 savings as described in this report, and estimate the savings to producers (commuters, businesses and governments).	Integrate active mode improvements with complementary strategies such as public transit improvements, efficient pricing, and smart growth policies.
Labor productivity – improved worker access to education and employment opportunities.	Degree that improved affordable modes improve access to education and employment.	Target commuter improvements and integrate with public transit to major employment centers.
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 traffic and parking lanes for 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 are reduced; this is not necessarily true. In many cases, improving access by alternative modes and streetscaping supports local economic development overall.

During the 1970s some cities had negative experiences with pedestrianized 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. 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 (Buchanan 2007). Clifton, et al. (2013) found that shoppers who arrive walking, cycling or public transport tend to spend less per trip but make more trips per month, and 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, 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 Toronto, Canada retail businesses 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.

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.

Active Transport Impacts on Business Activity

The following studies evaluate how pedestrian and cycling access effect retail activity.

ACA (2013), *United States Bicycle Route System Economic Impacts*, Adventure Cycling Association (www.adventurecycling.org); at www.adventurecycling.org/routes-and-maps/us-bicycle-route-system/benefits-and-building-support/economic-impact. Great source of information on cycling economic benefits.

CATSIP (California Active Transportation Safety Information Pages), *Case Studies: Complete Streets* (http://catsip.berkeley.edu/walkbikesafer/Complete%20Streets).

CALTRANS (2014), *Main Street, California: A Guide for Improving Community and Transportation Vitality*, California Department of Transportation (http://bit.ly/1Ny89nY).

Gary Hack (2013), *Business Performance in Walkable Shopping Areas*, Active Living Research (http://bit.ly/1BWXNtp). Indicates that walking improvements tend to increase commercial activity and land values.

T. Fleming, S. Turner and L. Tarjomi (2013), Reallocation of Road Space, Research Report 530, NZ Transport Agency (http://bit.ly/1KHRDDb). Comprehensive study found sales increases with more multi-modal street planning.

CABE (2007), *Paved with Gold: The Real Value of Street Design*, Commission on Architecture and the Built Environment (www.cabe.org.uk); at www.apho.org.uk/resource/item.aspx?RID=92342 . Shows how good street design can provide economic benefits and public value. Typical street improvements increase property values 5%.

Marc Schlossberg, John Rowell, Dave Amos and Kelly Sanford (2013), *Rethinking Streets: An Evidence-Based Guide to 25 Complete Street Transformations*, University of Oregon (www.rethinkingstreets.com).

Fred Sztabinski (2009*), Bike Lanes, On-Street Parking and Business A Study of Bloor Street in Toronto's Annex Neighbourhood*, The Clean Air Partnership (www.cleanairpartnership.org); at http://bit.ly/1CS7kDk. Found that most Toronto commercial street customers arrive by walking, cycling or public transit, and that improving pedestrian and cycling facilities can support local economic development, even if it reduces parking supply.

SDOT (2011), *Neighborhood Business District Access Intercept Survey*, Seattle Department of Transportation; at www.seattle.gov/transportation/intercept_survey.htm. This survey of patrons at six Seattle business districts found that most residents walk or take transit to get to neighborhood districts.

Kyle Rowe (2013), *Bikenomics: Measuring the Economic Impact of Bicycle Facilities on Neighborhood Business Districts*, University of Washington (http://bit.ly/1EH4TTp). Reviews research concerning bicycle facility impacts on local economic activity. Survey finds substantial (up to 400%) increases in local sales after bicycle lane installation.

Rodney Tolley (2011), *Good For Busine$$ - The Benefits Of Making Streets More Walking And Cycling Friendly*, Heart Foundation South Australia (www.heartfoundation.org.au); at http://bit.ly/19RTEe9. Found that walking and cycling improvements tend to increase property values, attract new businesses, and increase local economic activity. Concludes that bike parking provides more spending than the same space devoted to car parking.

NYCDOT (2012), *Measuring the Street: New Metrics for 21st Century Streets*, New York City Department of Transportation (www.nyc.gov/html/dot/downloads/pdf/2012-10-measuring-the-street.pdf). City uses indicators of economic vitality (sales receipts, commercial vacancies, number of visitors) when evaluating street improvements.

Luis Rodriguez (2010), *Pedestrian-Only Shopping Streets Make Communities More Livable*, Planetizen; at www.planetizen.com/node/47517. Discusses pedestrian-only commercial streets. It describes various successes.

Ray Straatsma and Tom Berkhout (2014), *Bikes Mean Business: Building A Great Cycling (And Walking) City*, Greater Victoria Cycling Coalition (http://bit.ly/1whqNeo). Downtown survey found that only 23% of downtown customers arrived by automobile and they tend to spend less per month than those who arrive by other modes.

Costs

Various costs associated with non-motorized transportation are discussed below.

Facility Costs

Although there is no single source of information on active mode infrastructure costs and expenditures, various studies provide estimates.

- Sidewalk construction typically costs $5-10 per square foot, totaling $1,250-2,500 for a 5-foot sidewalk on a 50-foot house frontage. This averages about $50 per year or $20 per capita assuming 2.5 residents per household. This suggests that construction and maintenance of a comprehensive sidewalk network probably costs $30-50 annually per capita.
- Using detailed field surveys in Albuquerque, New Mexico, Corning-Padilla and Rowangould (2020) estimated that improving all sidewalks to optimum standards would cost $54 million, which is approximately $60 per capita or $3 annual per capita over a 20-year operating life.
- A city engineering study found that approximately 40% of Denver, Colorado's sidewalks are missing or substandard, and filling these gaps would cost between $700 million or about $1,000 per capita (DE 2025). The city's new Ordinance 307 will collect special property taxes to upgrade and complete the city's sidewalk and recreational trail network over three decades.
- Ithaca, New York charges $70 annually per household (about $30 annual per capita) and $185 per business to build and maintain city sidewalks (Ithaca 2014).
- The city of Los Angeles has an estimated 10,750 miles of sidewalks, of which roughly 40% are inadequate. A 2016 class-action lawsuit by disability rights advocates requires L.A. to spend $1.4 billion over 30 years to fix its sidewalks, which averages $12 annual per capita, implying that replacing all sidewalks costs about $30 annually per capita (Shoup 2022).
- The *Nonmotorized Transportation Pilot Program* invested about $100 per capita in pedestrian and bicycling improvements in four typical U.S. communities (Columbia, MO; Marin County, CA.; Minneapolis, MN; and Sheboygan County, WI), which increased walking trips 23% and bicycling trips 48%, reduced total vehicle-miles about 3%, and increased walking and bicycling safety (FHWA 2014).
- The Washington State Department of Transportation 2020 *Draft Active Transportation Plan* estimates that upgrading the state transportation system to maximize active travel safety would cost $5.7 billion or approximately $750 per capita. If implemented over ten years it would cost about $75 annual per capita or 13% of the WSDOT budget (Weinberger 2021; WSDOT 2020).
- Dutch cities typically spend €10 to €25 annually per capita on bicycling facilities, which is considered high (Fietsberaad 2008). Federal and state departments of transportation typically spend $1 to $3 annually per capita in active transportation facilities (ABW 2018; Jones 2021).
- The study, *Cost Analysis of Bicycle Facilities* (Weigand, McNeil and Dill 2013) includes cost estimates of typical active transportation facilities including bikeways, signage, traffic calming and end of trip facilities.

The table below summarizes costs of various active transportation facilities, although more specific cost data should be used when available.

Table 10 **Typical Facility Costs** (FDOT 2003; Zegeer, et al 2002; Krizek, et al. 2006)

Measure	Typical Costs (2012 U.S. Dollars)
Sidewalks (5-foot width)	$20-50 per linear foot
Marked crosswalk	$100-300 for painted crosswalks, $3,000 for patterned concrete.
Pedestrian refuge island	$6,000-9,000, depending on materials and conditions.
Path (5-foot asphalt)	$30-40 per linear foot
Path (12-foot concrete)	$80-120 per linear foot
Bike lanes	$10,000-50,000 per mile to modify existing roadway (no new construction)
Bicycle parking	$100-500 per bicycle for racks, and $2,000 per locker
Center medians	$150-200 per linear foot
Curb bulbs	$10,000-20,000 per bulb
Curb ramps	$1,500 per ramp.
Chokers	$7,000 for landscaped choker on asphalt street, $13,000 on concrete street.
Curb bulbs	$10,000-20,000 per bulb.
Traffic circles	$4,000 for landscaped circle on asphalt street, $6,000 on concrete street.
Chicanes	$8,000 for landscaped chicanes on asphalt streets, $14,000 on concrete streets.
Traffic signs	$75-100 per sign.
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.

These studies indicate that typical North American communities currently spend $30 to $60 annually per capita on active mode facilities (sidewalks, bike networks and bike parking), either through government expenditures or mandates for property owners to build and maintain sidewalks.

Vehicle Traffic Impacts
Some non-motorized improvements can cause vehicle traffic delays. For example, traffic calming and speed reductions, wider sidewalks, bike lanes, and increased 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 require 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 generally smaller 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 costs more than gasoline per calorie, but the amounts are generally small (a 150-pound person burns 80 calories per mile walked, and half that when cycling), and since most people enjoy eating and consume more calories than optimal, this food consumption is often 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. 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). Improving pedestrian and cycling connectivity, and more compact 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 depending on conditions and preferences ("Travel Time Costs," Litman 2009; Mackie, et al. 2003). Under favorable conditions active travel has low or negative time costs; users often consider time spent walking and bicycling a benefit rather than a cost because it is enjoyable and provides exercise which reduces the need to spend special time exercising, so users may choose these modes even if they take longer than driving (Björklund and Carlén 2012; Standen 2018). 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 vary. 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 prefer, considering all benefits and costs.

Evaluating Impacts: Various methods can be used to measure the value users place on their travel time ("Travel Time Costs," Litman 2009; Standen 2018). 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

The following table summarizes potential active transport benefits and costs.

Table 11 **Summary of Active Transport (AT) Benefits and Costs**

Impact Category	Description
Improve AT 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
More AT Activity	*Benefits from increased walking and cycling activity*
Fitness and health	Improved public fitness and health
Reduced Auto 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.

This table categorizes these impacts.

Table 12 **Active Transportation Benefits and Costs**

	Improved Active Travel Conditions	Increased Active Travel	Reduced Auto 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 has various benefits and costs.

Not all active transport improvements have all of 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 improving 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.

The table below 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 13 **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 support strategic planning objectives?*
Describe impact				
How much				
Who is affected				

Fill in this table to 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 miles 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

This table 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.

Table 14 **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

The following table 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 15 **Increased Walking and Cycling Activity** (Per Person-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.

Reduced Automobile Travel

The table below 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 help create more compact and mixed land use development.

Table 16 **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. Impacts are measured in "mils" (a thousandth of a dollar) per passenger-mile.

Land Use Impacts

The table below 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 17 **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

This table summarizes the typical costs of improving non-motorized conditions and increasing active travel.

Table 18 **Typical Values – Walking and Cycling Costs**

Impact Category	Urban Peak	Urban Off-Peak	Rural	Average	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	0.083	0.083	0.083		

This table summarizes potential active transport benefits and costs.

Active Transport Improvement and Encouragement Strategies

There are many possible ways to improve and encourage active transport (Alta Planning 2005; Bhattacharya, Mills, and Mulally 2019; ITF 2023). 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.
- *Cool walkability planning* to ensure pedestrian thermal comfort in hot climate cities (Litman 2023a). This can be accomplished by creating integrated networks of *shadeways* (shaded sidewalks) and pedways (enclosed, climate-controlled walkways).
- *Bike sharing* (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*. Programs that encourage the use of resource-efficient modes for travel 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 the use of active modes by reducing the distances people must travel to reach common destinations such as shops, schools, parks, public transit, and friends (Ewing and Hamidi 2014).

The following table 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). An integrated program that includes active mode improvements plus incentives to shift mode can typically reduce automobile travel by 10-30%.

Table 19 **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).

ABW (various years), *Bicycling and Walking in the U.S.: Benchmarking Reports*, Alliance for Biking & Walking (www.peoplepoweredmovement.org); at http://bikingandwalkingbenchmarks.org.

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.

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.

Marcel Moran, Milik Salman, Takahiro Yabe (2026), "Heterogeneous Impacts of Protected Bike Lanes on Bikeshare Behavior Across Demographic Groups in New York," *Sustainable Mobility and Transport* (doi.org/10.1038/s44333-026-00107-2).

National Association of City Transportation Officials (http://nacto.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.

NACTO (2013), *Urban Street Design Guide*, National Association of City Transportation Officials (http://nacto.org); at http://nacto.org/publication/urban-street-design-guide.

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.

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

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.

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 may reduce driving. Pedestrians can 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); 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 synergistic effects so benefits increase as the network expands. A single sidewalk improvement may provide minimal benefit, while a link that connects two otherwise isolated networks or provides a shortcut 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 in the area, so total benefits are likely to be greater than property value changes indicate (Clark and Davies 2009).

Factors affecting pedestrian infrastructure improvement benefits

Magnitude of improvement

- Whether it significantly improves pedestrian conditions.

Demand

- Number of potential users, including youths, people with disabilities or low incomes, seniors, dog owners, and people who want to walk for exercise.
- Importance of destinations it accesses, such as schools, businesses, 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.

Using economic modelling, Standen (2018) found that Sydney, Australia bicycle network improvements offer substantial welfare benefits to users, in terms of improved accessibility, comfort, perceived safety, and transport choice, even if the trips are slower, and these benefits increase with network connectivity. By ignoring such benefits in project appraisal, bicycle facilities may be significantly undervalued, and transport investment decisions inadequately informed.

Bicycle facilities tend to have network effects, so benefits increase as the network expands. A short, isolated length of bike path 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.

Critics often focus on direct impacts but ignore larger effects. For example, bike lanes that displace traffic or parking lanes are sometimes criticized for increasing traffic or parking congestion *on that stretch of road*, but if they cause shifts from driving to bicycling, they can reduce traffic and parking problems over a large area.

Factors affecting bicycle network benefits

Magnitude of improvement
- Whether located on or parallel to a busy roadway where cycling is otherwise difficult.
- If it is 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.
- Importance of destinations it accesses, 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
- If it connects to a large cycling network.
- If it is part of an integrated program of to improve alternative modes and support smart growth.

Active and Micro Mode Travel Impacts and Benefits

Active and motorized micro modes can substitute for a significant portion of automobile travel. Surveys indicate that many people want to use these modes more often, for enjoyment, health, and affordability (NAR 2017). According to the *National Household Travel Survey* approximately 12% of total personal trips in the U.S. are made by active modes, but their potential use is much greater (Kuzmyak and Dill 2012). Approximately a quarter of all urban trips are one mile or less, suitable for a twenty-minute walk; half of all vehicle trips are three miles or less, suitable for a twenty-minute bike ride; and most trips are less than five miles, suitable for a twenty-minute e-bike ride (Bhattacharya, Mills, and Mulally 2019). These researchers estimate that active mode improvements can deliver $74-138 billion in annual value, taking into account user savings, public health, economic growth and opportunity, and environmental quality.

One Dutch survey found people who purchase an e-bike increased bicycling from 2.1 to 9.2 average daily kilometers and reduced their car travel from 5.1 to 4.6 average daily kilometers (Fyhri and Sundfør 2020). A major academic study, *A Global High Shift Cycling Scenario*, estimated that improving bicycle and e-bike conditions could increase urban bicycling mode shares from the current 6% up to 17% in 2030 and 22% in 2050 (Mason, Fulton and McDonald 2015). Other studies in North America (McQueen, MacArthur, and Cherry 2020) and Europe (Bucher et al. 2019) estimate that, accounting for various climatic and geographic constraints, e-bikes could achieve 10-15% mode shares and produce up to 12% emission reductions in typical urban areas.

Active Transport Education and Encouragement Programs

Education and encouragement programs reduce barriers to active travel (ignorance, social stigma, a habit of driving), increase use of these modes, and reduce motor vehicle travel. Such programs complement facility improvements by increasing their use and therefore their total benefits.

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).
- Whether 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.

Cool Walkability Planning

As the world becomes hotter and more urban, pedestrians increasingly experience excessive heat, particularly in cities due to the *heat island effect* (higher ambient temperatures in built up areas. This makes urban walking uncomfortable, unattractive and dangerous, which is harmful and unfair to pedestrians, and encourages more automobile travel and sprawl. To reduce these problems hot-climate cities should plan for pedestrian thermal comfort. This can be accomplished by creating integrated networks of *shadeways* (shaded sidewalks) and *pedway*s (enclosed, climate-controlled walkways) that connect homes, commercial buildings and public transport within walkable *urban villages* (compact neighborhoods where most services and activities are easy to reach without driving). Although these cost more than basic sidewalks they greatly improve walking comfort and are far cheaper than motor vehicle infrastructure. They can provide many economic, social and environmental benefits. Pedway and shadeway networks can often repay their costs through road, parking and vehicle savings, and by increasing local business activity and property values.

Bikesharing

Bikesharing and *Community Bike Programs* provide convenient rental bicycles intended for short (less than 5 kilometers), 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 system 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.

Determining 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

The table below 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 20 **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*	*$14,300.00*

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 an 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

The table below 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 considering 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 21 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*	*$645,365.00*

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

The following table shows the monetized benefits from a commute trip reduction program that convinces 100 employees to shift from driving to active modes, assuming their commutes average 5 miles per day for 240 days per year, and they pay $5.00 per day for parking. 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 22 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*	*$875.00*

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

Active Transport Evaluation Examples and Case Studies

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

Pedestrians First Tools for a Walkable City (https://pedestriansfirst.itdp.org).

Pedestrians First is a set of interactive tools that measure walkability in cities around the world. They describe why and how communities can improve and encourage walking, including complementary strategies such as improving public transit and Smart Growth development.

Active Travel Benefit Analysis

Jacob, et al. (2021) reviewed studies of interventions to increase active travel to schools. They found that interventions that improve infrastructure and enhance the safety and ease of active travel to schools generate societal economic benefits that exceed the societal cost. Similarly, Jacob, et al. (2024) concluded that park, trail, and greenway investments generally provide net benefits due to improved public fitness and health.

Promoting Walking and Cycling Toolkit (WHO 2025)

The World Health Organization's *Promoting Walking and Cycling: A Toolkit of Policy Options* provides specific information concerning why (health, road safety, environment, economy, equity and mobility) and how (provide safe walking and cycling networks, design inclusive streets, improve travel behavior, prioritize and promote active travel) to increase active travel.

Active Transport Benefits to Society (Pisoni, Christidis, and Cawood 2022)

The article, *Active Mobility Versus Motorized Transport? User Choices and Benefits for the Society* analyzed factors that affect urban walking and bicycling activity, estimated the potential for increased active travel, and using the European Commissions' *Handbook on the External Costs of Transport,* estimated potential cost savings from shifts from driving to active travel. It estimated that each 10% of trips shifted provides annual benefits totalling at least 15 billion euros.

Global (WB 2023)

The report, *The Path Less Travelled: Scaling Up Active Mobility to Capture Economic and Climate Benefits*, by the World Bank and Institute of Transportation and Development Policy, examines why and how cities in low- and middle-income countries can improve and encourage walking, bicycling, and public transport to help achieve economic, social and environmental goals. By enabling more active and public transport use, large-scale interventions to scale up active mobility can deliver significant, quantifiable benefits that dwarf the upfront costs. For example, large public transit projects become more effective and cost effective if implemented with walking and bicycling improvements that improve access to transit stations and support more transit-oriented development. This paper makes a case for scaling up financing, leveraging lessons learned, and identifying and replicating successful investment mechanisms from case studies. It recommends:

- Build internal capacity to institutionalize active mobility and scale up investments.
- Develop a standardized cost-benefit analysis framework to evaluate active mobility projects.
- Consider active mobility as a core component of an integrated urban mobility planning.
- Recognize the interdependency between transport, urban, public health and public space planning
- Use active mobility as a pathway to advance broader urban mobility goals (e.g., increasing access to public transport and public transport ridership, road safety, etc.)
- Cycling promotion should include cycle lanes, bikeshare programs, bicycle parking and capacity building

- Work together and build coalitions that encourage blended financing for active mobility projects

Understanding Street Improvement Economic and Business Impacts (Liu and Shi 2020)

The National Street Improvements Study researched the economic effects of bicycle infrastructure on 14 corridors across six cities — Portland, Seattle, San Francisco, Memphis, Minneapolis and Indianapolis. It found that improvements such as bicycle and pedestrian infrastructure had either positive or non-significant impacts on the local economy as measured through sales and employment.

For example, after bike lanes were installed on Central Avenue in Minneapolis in 2012, local retail employment increased 13%, compared with a 8.5% increase in a control area a few blocks away. It also recorded a dramatic 52% increase in food sales, more than doubled the 22% increase in the control area. A protected bike lane along Broadway in Seattle was accompanied by a significant 31% increase in food service employment compared to 2.5% and 16% increases in control areas.

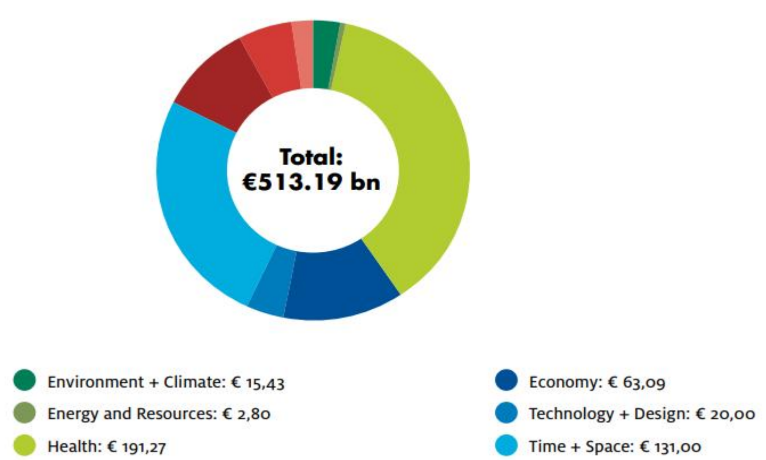
Econometric of Active Transport User Benefits (Standen 2018)

Using detailed travel surveys and discrete choice modelling, Christopher Standen found that Sydney, Australia bicycle network improvements offer substantial welfare benefits to users, in terms of improved accessibility, comfort, perceived safety, and transport choice – even though their journeys may end up being slower, and these benefits tend to increase with network connectivity. By ignoring such benefits in project appraisal, bicycle facilities may be significantly undervalued, and transport investment decisions inadequately informed.

European Cycling Benefits

The EU Cycling Economy – Arguments for an Integrated EU Cycling Policy (Neun and Haubold 2016) estimates various bicycling benefits including environmental benefits from reduced pollution and impervious surface, health and safety benefits, bicycle and tourist industry productivity, user enjoyment, social equity, congestion reductions, road and parking facility cost savings, social equity and community connections. The figure below summarizes the results. The study identified various additional benefits that were not quantified due to inadequate information.

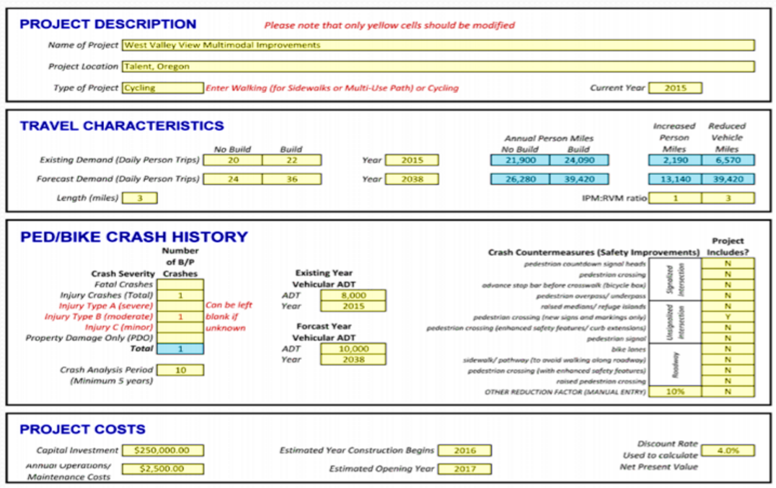
Figure 15 **EU Cycling Benefits Summary** (Neun and Haubold 2016)



The EU Cycling Economy report used various methods to estimate economic, social and environmental benefits of cycling in the European Union. This information is used to justify policies that support cycling.

Active Transportation Benefit/Cost Calculator
Transportation programs and projects are often evaluated using benefit-cost analysis, to ensure that their total benefits exceed their total costs, and to compare and prioritize potential projects. However, existing benefit-cost analysis tools are inadequate for evaluating active transport. To fill this gap the California Department of Transportation developed the *Active Transportation Benefit-Cost Calculator* (Cooper and Danziger 2016; www.dot.ca.gov/hq/tpp/offices/eab/atp.html). Many of the methods and values used in the Calculator are based on this report.

Figure 16 **Benefit-Cost Calculator Interface** (Cooper and Danziger 2016)



The Active Transportation Benefit-Cost Calculator is a spreadsheet model that can be used to calculate the net benefits of a pedestrian or cycling project. It uses many of the concepts and values presented in this report.

The Tool incorporates the following impacts:

- Project costs
- Changes in travel activity
- Changes in crashes
- User benefits
- Physical fitness and health benefits from more active transport
- Various savings from projects that reduce motor vehicle travel
- Benefits from projects that encourage more compact development

The current version tends to underestimate some benefits such as reduced chauffeuring burdens and parking cost savings, based on the assumption that they are difficult to calculate, and applies a high value to time spent walking and bicycling, ignoring many people's enjoyment of these activities. However, the model can be adjusted to account for these factors. Despite these weaknesses, this tool is a major contribution to active transportation economic evaluation.

Active Transportation Benefits Study (Urban Design 4 Health 2017)
This study estimates various benefits and costs of bicycling and walking in Utah including government expenditures on bicycle facilities, user expenditures on vehicles and operation (e.g., food), expenditures by tourists, and reduced healthcare and absenteeism costs. It proposes a program to collect data to measure these impacts and promote these benefits.

Evaluating Innovative Modes
The report, *Innovative Active Travel Solutions and Their Evaluation* (Ognissanto, et al. 2018) evaluated various impacts (particularly health impacts) of innovative active travel modes including bicycling, skateboards, scooters and electrically assisted vehicles such as Electrically Assisted Pedal Cycles (e-bikes), powered scooters, skateboards, hoverboards and Segway scooters (Personal Light Electric Vehicles). The study also examined the infrastructure requirements of these modes, their legal status, and public policies that could support their use.

Danish Cycling Evaluation
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 (COWI 2009). The table below summarizes methods used to evaluate cycling project impacts on travel activity (the amount of cycling and automobile travel).

Table 23 **Assessing Effects of Cycle Initiatives** (COWI 2009)

Effect for Economic CBA	Methods 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 travel time by 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 accident rates.	Accident reports, interviews and traffic counts and 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.

The following table 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 value would be even higher under urban-peak conditions due to higher congestion costs.

Table 24 **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.

European Cycling Benefits Study (ECF 2018)
The European Cycling Federation (ECF) estimates that cycling provides annual benefits that 150 - 155 billion euros, with “longer and healthier lives” and “cycle tourism” being the two most valuable benefits. Smaller benefits include motor vehicle infrastructure saving, reduced traffic congestion, bicycle market, fuel savings, plus reduced noise and air pollution.

British Cycling Evaluation (Rajé and Saffrey 2016)
A comprehensive literature review concerning cycling economic evaluation suggests that cycling can provide diverse benefits and help achieve many strategic goals, but conventional appraisal methods do not incorporate the full extent of these benefits, and overlooks many costs of motorized transport, resulting in underinvestment in this mode.

Australian Active Transport Assessment Guidelines
The Australian Department of Infrastructure and Regional Development’s Transport Assessment and Planning Steering Committee provides specific guidelines for transportation project evaluation, including active transport, as described in, *Australian Transport Assessment Planning Guidelines – M4 Active Travel* (ATAP 2016). It includes monetized values for:

- Improved health outcomes.
- Reduced traffic congestion.
- Changes in safety risk.
- Changes in travel time.
- Changes in public transport fares and private vehicle parking and operating costs.

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 25 **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)

The Queensland *Active Transport Infrastructure Benefits Studies* (https://bit.ly/35Fr15r) provides a practitioner-friendly cost-benefit analysis tool for evaluating transport projects after completion.

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).

Bicycle Facility Impacts on Cycling Activity and Risk (NACTO 2017)

A study by the National Association of City Transportation Officials, *Equitable Bike Share Means Building Better Places for People to Ride* evaluated the relationships between bicycle facility development, cycling activity and bicycle crash rates. It found that:

- When cities expand protected bike networks, more people bicycle. Studies of North American cities indicate that such facilities increase bike ridership on those streets by 21% to 171%.
- Cycling becomes safer as cities build better bike lane networks. In five of the seven U.S. cities NACTO surveyed, the absolute number of bicyclists killed or severely injured declined from 2007 to 2014 despite increased cycling. Even in cities where bicycle casualties increased the increases were smaller than the increase in bicycling activity.
- Gains in bike safety are especially important for low-income riders and riders of color. 49% of the people who bike to work earn less than $25,000 per year, and Black and Hispanic bicyclists have a fatality rate 30% and 23% higher than white bicyclists, respectively. Building extensive protected bike lane networks benefits those who are most at risk.
- Approximately 60% of people surveyed are “interested but concerned” about biking and would bike with higher-comfort facilities. Of those, 80% would be willing to ride on streets with a separated or protected bike lane. In particular, recent national research suggests that that people of color are more likely than white Americans to say that adding protected bike lanes would make them ride more.
- Bike share systems should be matched with protected bike lane networks to encourage ridership and increase safety. People on bike share bikes make up a disproportionate number of the riders on protected lanes, and stations adjacent to bike lanes are busier than ones that are not. For bike sharing to be successful, people need to feel comfortable riding.
- The risk of a bicyclist being struck by a motorist declines as the number of people biking increases. Appropriately scaled bike share systems can dramatically increase the total number of people on bikes in a city and help build political momentum for bike lanes.
- Mandatory adult helmet laws reduce bike ridership and do not increase safety. Mandatory adult helmet laws have reduced bike ridership in Sydney, and hampered bike share ridership efforts in Melbourne and Seattle. In addition to evidence that mandatory adult helmet laws do not increase overall bike safety, reports from across the U.S. suggest that these laws are disproportionately enforced against people of color, further discouraging them from riding.

Active Transport Performance Indicators (Semler, et al. 2016)

The Guidebook for Developing Pedestrian and Bicycle Performance Measures is intended to help communities develop performance measures that can fully integrate pedestrian and bicycle planning in ongoing performance management activities. It highlights a broad range of ways that walking and bicycling investments, activity, and impacts can be measured and documents how these measures relate to goals identified in a community’s planning process. It discusses how impacts can be tracked and what data are required, and identifies examples of communities that are currently using these indicators. This report highlights resources for developing measures to facilitate high quality performance-based planning.

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. It 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.

Colorado Economic and Health Benefits of Cycling and Walking (BBC 2016)
Economic and Health Benefits of Bicycling and Walking (BBC 2016) estimated that bicycling and walking provide approximately $4.8 billion annual benefits in the state of Colorado, and a 60% increase in walking and cycling activity could provide an additional $1.5 to $2.3 billion worth of health benefits. It uses various sources to estimate walking and cycling activity in Colorado, including participation in special walking and cycling events, visitors who use these modes, and other benefit analysis methods. However, the study methods are incomplete and biased.

The study's safety benefits analysis only considers direct crash reductions from pedestrian and cycling infrastructure improvements, but fails to account for the "safety in numbers" effects, through which increased walking and cycling activity tends to reduce total traffic casualty rates in a community by reducing total vehicle traffic, reducing high-risk driving, and increasing driver awareness (Jacobson 2003; Murphy, Levinson and Owen 2017). Health benefits are estimated using the *Health Economic Assessment Tool* (WHO 2014), which, Mansfield and Gibson (2015) argue can overestimate health benefits. On the other hand, walking is a particularly appropriate way for people who are currently overweight and sedentary to become more physically active, and so may provide additional health benefits than conventional models assume.

As with many economic impact studies intended to promote a particular industry, it incorrectly treats walking and cycling expenditures as a benefit. For example, it would be wrong to assume, as they do, that purchasing an imported bike for $700 wholesale, and then selling it for $1,000 creates $1,000 in economic benefits in Colorado; at most, it creates $300 net revenue, but a more accurate method measures net productivity and employment gains using regional economic model. Probably the greatest true benefit is the ability of pedestrian and cycling improvements to allow households to reduce their vehicle ownership and use, and therefore shift their spending from vehicles and fuel to other goods with more regional inputs.

Pedestrian Improvements for Economic Development
A study titled, *The Relationship Between Pedestrian Connectivity and Economic Productivity in Auckland's City Centre*, (Rohani and Lawrence 2017) investigated the value of walkability (pedestrian connectivity) to the Auckland, New Zealand economy. The study used quantitative analysis to measure the contribution that walkability makes toward agglomeration efficiencies in commercial centers by facilitating face-to-face interactions that increase knowledge generation and sharing. The study found statistically significant positive associations between pedestrian access and labour productivity and concludes that commercial center walkability improvements can support economic development.

Justifications for Improving Cycling Conditions (Balsas 2017)

The article, *Blending Individual Tenacity with Government's Responsibility in the Implementation of US Non-motorized Transportation Planning (NMT)*, argues that public safety, health and fairness justify more efforts to create safe, accessible, convenient, comfortable, and attractive walking and bicycle facilities for everyone. It identifies a variety of conceptual, institutional and planning reforms needed by individuals, practitioners and agencies to achieve these goals.

Valuing Pop-up Bike Lanes (Kraus and Koch 2020)

The study, *Effect of Pop-up Bike Lanes on Cycling in European Cities*, evaluated the impacts of provisional bicycle infrastructure on cycling traffic in 106 European cities during the COVID-19 pandemic. It integrated daily bicycle counts spanning over a decade from 736 bicycle counters, and combine this with data on announced and completed pop-up bike lane road work projects. On average 11.5 kilometers of provisional pop-up bike lanes have been built per city. Each kilometer has increased cycling in a city by 0.6%. The researchers calculate that the new infrastructure will generate $3 billion in health benefits per year, if cycling habits are sticky.

Comparing Automobile and Cycling Cost in Copenhagen (Gössling and Choi 2015)

The study, *Transport Transitions in Copenhagen: Comparing the Cost of Cars and Bicycles*, compared total costs of automobile and bicycling. The analysis reveals that car travel is more than six times more costly (Euro 0.50/km) than cycling (Euro 0.08/km), and driving costs are likely to increase in the future while cycling costs appear to be declining.

Neighborhood Design and Health

Access to neighborhood parks also affects residents' physical activity and health. The study, "Where Matters: Health & Economic Impacts of Where We Live," found the following impacts of neighborhood walkability or park proximity.

Table 26 **Health Impacts of Walkability and Park Access** (Frank, et al. 2022)

	Walkable Compared with Auto-Dependent	Many Parks Compared with No Parks
Physical Activity	45% more likely to walk for transportation and 17% more likely to meet physical activity targets.	20% more likely to walk for leisure or recreation and 33% more likely to meet the physical activity targets.
Obesity	42% less likely to be obese.	43% less likely to be obese.
Diabetes	39% less likely to have diabetes.	37% less likely to have diabetes.
Heart Disease	14% less likely to have heart disease.	39% less likely to have heart disease.
Stress	23% fewer stressful days.	19% fewer stressful days.
Sense of Community	47% more likely to have a strong sense of community and belonging.	23% more likely to have a strong sense of community and belonging.

Neighborhood Walkability and park access can significantly affect residents' health.

Recommendations for Comprehensive Evaluation

As this report discusses, conventional economic evaluation tends to consider a limited set of active transport benefits and so tends to undervalue active transport improvements (Makarewicz, et al. 2019; Rajé and Saffrey 2016; Semler, et al. 2016). 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 (Srivastava, Srivastava and Rana 2025).

Below are guidelines for comprehensive active transport evaluation.

- Recognize the many roles that active modes 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, transit access trips, plus recreational walking and bicycling.
- Consider factors that can increase active travel demands including aging population, rising fuel prices, increased urbanization, and rising health and environmental concerns. Also consider latent demand and therefore the increased active travel that result from improved walking and bicycling 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.
- Use appropriate methods for measuring economic impacts, which measure overall net impacts on economic productivity and incomes. Do not simply treat consumer expenditures on walking and cycling equipment as economic benefits.
- Consider active transport's leverage effects on automobile ownership and use; in appropriate conditions, each additional mile of walking and cycling can reduce 5-10 miles of automobile travel, particularly if pedestrian and cycling improvements reduce automobile ownership or help create more compact communities. This can significantly increase 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 are 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, 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 cost 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 are an unfair *diversion* of money that should be dedicated to roadway facilities. This belief 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 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 indirect vehicle travel reductions and additional benefit categories.

It is useful to frame impact analysis results to be understandable and relevant. For example, some evaluations calculate millions or billions of dollars of estimated benefits, numbers that are too large and theoretical for most people to appreciate. It is often best to present analysis results in annual savings and benefits per capita, or compared with the full costs of automobile travel required to provide access. It is reasonable to say, for example, that active transportation improvements that allow households to own one fewer automobiles typically provides $5,000 to $10,000 in direct savings to those households, plus similar value benefits worth of road and parking infrastructure savings, traffic safety and health benefits, environmental benefits, and local economic development; methods described in this report can support those conclusions.

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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