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Transportation Cost Estimates

A summary of the costs to users and communities of various travel modes

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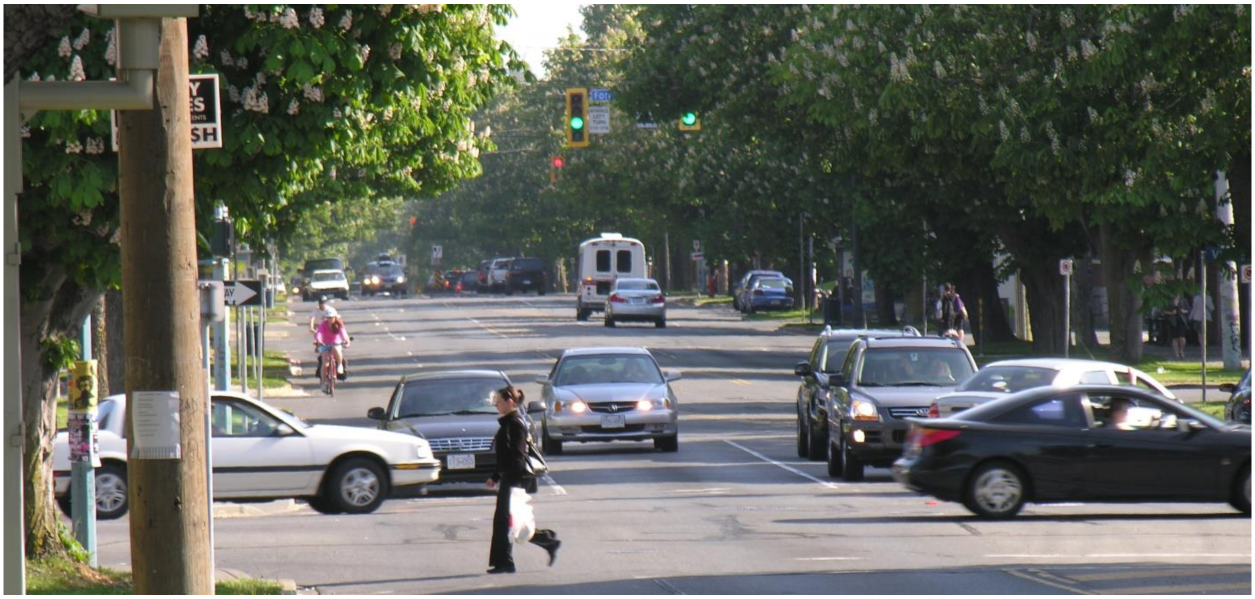
By Todd Litman



All forms of travel impose costs on users and communities, but these costs vary widely depending on mode and conditions.

Summary

This report describes ten transportation costs (financial subsidies, vehicle ownership, vehicle operation, roadway infrastructure, parking facilities, traffic congestion, barrier effect, crash damages, noise and air pollution, and resource externalities.) and estimates their magnitude for six modes (walking, bicycling, e-bikes, public transit, fossil fuel and electric cars). Transportation is the second largest household expenditure category, after housing, transportation infrastructure – roads and parking facilities – are a major cost to governments and businesses, and vehicle travel imposes external costs including congestion delays, crash risks and pollution damages. Although all forms of travel impose some costs (even walking requires sidewalks and paths), automobile costs are much higher than other modes. This is inefficient and unfair; it results in economically excessive vehicle travel, and causes people who drive less than average to subsidize the costs of those who drive more than average. Since vehicle travel tends to increase with income, this is regressive: lower-income tend to subsidize more affluent motorists.

For more information see, *Transportation Cost and Benefit Analysis* (www.vtpi.org/tca).

Introduction

Transportation affects our lives and communities in many ways. Most people devote more than an hour each day to personal travel, and the nature of this travel experience can directly affect our comfort and happiness, and our interactions with our community: the time we spend travelling can be pleasant and social, or the worst part of our day.

Transportation, particularly motor vehicle travel, is a major household expense, including many indirect costs included in our mortgage, rents, general taxes and the prices of other goods to pay for transportation infrastructure such as paths, roads and parking facilities. The mobility and accessibility options available to us affect our economic and social opportunities, and therefore a community's economic productivity and equity. How we travel affects our health and safety.

Vehicles require expensive infrastructure; every time somebody purchases an automobile they expect governments to build roads to drive on, and businesses to provide off-street parking for their use, plus permission to impose external traffic costs including congestion delays, crash risks and pollution imposed on other people. Many people assume that user fees cover these costs, but fuel taxes and tolls only pay about half of roadway costs, the rest are funded through general taxes, and parking costs are incorporated into mortgages, rents, and the prices of other goods. For example, an average household pays several hundred dollars in local taxes to pay for local roads and traffic services, and parking subsidies add a few cents to the cost of a beer at your local pub, a few dollars to the cost of a restaurant meal, and several dollars to your monthly food bill – which all customers pay regardless of whether or not they arrive by car.

Although all forms of travel impose costs (even walking requires sidewalks and paths), automobile travel external costs are much higher than other modes, so people who drive less than average subsidize the costs of those who drive more than average. External costs are both economically inefficient and unfair; they result in economically excessive vehicle travel, and they cause people who use resource-intensive modes, such as automobiles, to impose net costs on travellers who use resource-efficient modes such as walking, bicycling and public transit, and since vehicle travel tends to increase with income, this is regressive: lower-income often subsidize the costs of more affluent motorists.

Conventional transportation planning tends to consider some of these costs but often overlooks others. For example, planning decisions, such whether to expand roadways, develop bikeway networks or improve public transit services, often overlook vehicle ownership and parking costs, and therefore many savings to travellers and businesses that result when people shift from driving to walking, bicycling and public transit. More comprehensive analysis of these costs can help improve transportation planning and policy analysis, and achieve planning goals related to affordability and social equity.

Cost Estimates

This section defines and estimates various transportation costs.

Subsidies

Some modes receive financial subsidies. About one-third of U.S. public transit expenses are funded by fares and two-thirds by subsidies, but it is not appropriate to assign this cost totally to users. Transit subsidies are provided, in part, for option value for non-users, so the service is available if needed, like a lifeboat on a ship (Geurs, Haaijer and Van Wee 2006). Subsidies are needed largely to maintain service at times and locations with low demand, and to provide special services to people with special needs. In addition, transit travel has low marginal costs and strong scale economies: an additional passenger on an uncrowded bus or train imposes minimal costs and increases efficiency. As transit ridership increases in an area, cost recovery ratios increase to the point that high ridership routes fully recover their costs. This analysis assumes that marginal user subsidies are half of user costs.

Electric vehicles currently receive Corporate Average Fuel Economy (CAFE) credits that currently average $3,000-6,000 per vehicle (for example, during the second quarter of 2020 Tesla sold 90,000 vehicles and received $428 million in credits, averaging $4,700 per vehicle), purchase subsidies averaging about $5,000 per vehicle, public investments in recharging stations that often provide free electricity (commercial stations typically charge $2.50 per recharge), plus road user fuel tax exemptions averaging about $310 per vehicle-year, as summarized below. This indicates that for the foreseeable future, electric vehicle subsidies total about $1,000 per vehicle-year.

Table 1 **Typical Electric Vehicle Subsidies** (www.fueleconomy.gov)

Subsidy	Annual Value
Corporate Average Fuel Economy (CAFE) credits ($4,700 over 15 years)	$313
Purchase subsidy ($5,000 over a 15-year vehicle life)	$333
Electric vehicle recharging stations (50 free annual recharges costing $2.50)	$125
Road user fee exemption (12,500 annual miles, 20 mpg, 50₵ tax per gallon)	$310
Total Annual Subsidy	*$1,081*

Electric vehicles currently receive subsidies that average more than $1,000 per vehicle-year.

Vehicle Ownership

This includes fixed user expenses such as vehicle depreciation, financing, insurance and maintenance. Walking and public transit have no significant fixed costs. Bicycling is estimated to have $100 annual fixed costs, assuming that a new bike costs $1,000 and lasts ten years, and e-bikes twice that.

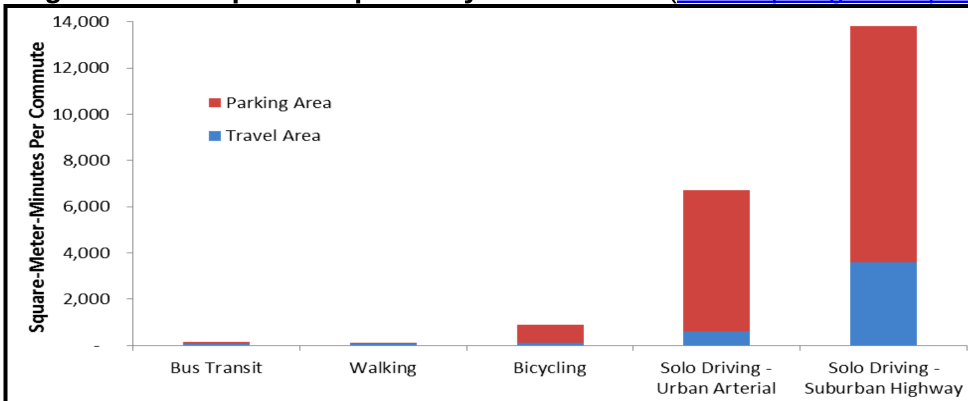
According to the U.S. *Consumer Expenditure Survey* (BLS 2018), in 2018 motorists spent an average of $4,707 per vehicle, although this is probably an underestimate since motorists tend to overlook and underestimate many vehicle expenses including depreciation, residential parking, repair, crash damages and traffic violation fees (Andor, et al. 2020). This analysis estimates that an average automobile has $3,000 annual fixed costs. Electric vehicles currently have higher purchase prices than comparable fossil fuel vehicles; this analysis assumes $5,000 annual fixed costs. Some experts predict that declining battery costs will soon make electric vehicles cheaper than fossil fuel vehicles, but motorists tend to use such efficiency gains to purchase larger battery sets for better performance (speed, capacity and distance) rather than to save money, so electric vehicles will probably be relatively costly for the foreseeable future.

Vehicle Operation
This includes variable expenses that increase with distance travelled, including fuel, tire replacement, repairs, road tolls and parking fees. Since most people own shoes, walking marginal costs reflect additional replacement or repair costs, estimated to total $100 annually for somebody who walks 1,000 annual miles. Bicycling 2,000 annual miles is estimated to have $200 per year additional repair and maintenance costs, although these costs are lower for cyclists who maintain their own bikes. E-bikes are estimated to cost twice as much. Public transit travel is estimated to cost $800 annually, reflecting a combination of frequent users who purchase monthly passes and less frequent users who purchase individual fares.

This analysis assumes that fossil fuel vehicles have $2,000 annual operating costs. Electric vehicles are estimated to have $1,000 annual operating costs, since typical electric vehicle uses 3-12₵ worth of electricity per mile, about half the fuel costs of an equivalent gasoline car, but this many be an underestimate since electric vehicle batteries must be replaced about every 100,000 miles, which currently costs $3,000-15,000 or 3-10₵ per vehicle-mile. Due to their low operating costs, electric cars are assumed to travel about 20% more annual miles than a comparable gasoline car which increases many of the external costs described below.

Roadway Facilities
In 2018, government roadway expenditures averaged $814 per vehicle, about half of which is funded by user fees, such as fuel taxes and road tolls, and half are funded through general taxes (FHWA 2018, Table HF10). These estimates only reflect current roadway expenditures and do not count the opportunity costs of land used for road rights of way, which many economists argue should be considered a roadway costs (Levinson 2018), or the costs of traffic services such as street lighting and traffic law enforcement. Larger vehicles, including buses, impose greater roadway costs per vehicle-mile, but less per passenger-mile. This analysis assumes that roadway costs average $800 per vehicle-year for gasoline cars, of which half is internal, paid through road user fees, and $1,000 per vehicle-year for electric cars due to their greater weight and annual mileage, which are entirely external.

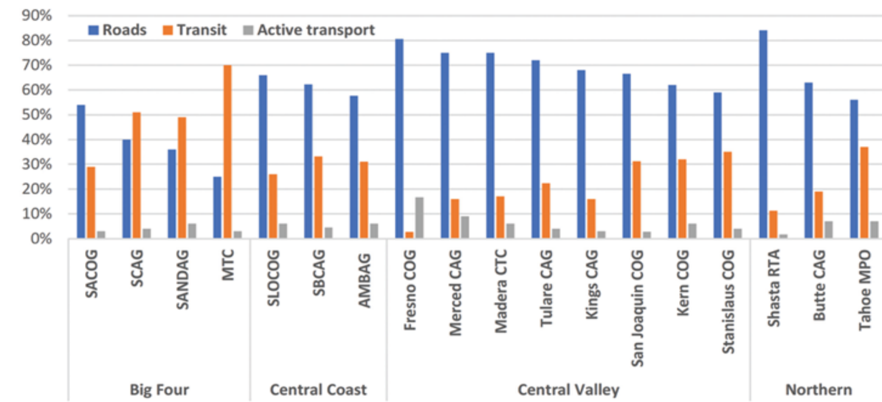
Figure 1 **Space Required By Travel Mode** (www.vtpi.org/Transport_Land.xls)



Automobile travel requires far more space for travel and parking than other modes.

Walking and bicycling have much lower facility costs, although these are difficult to quantify since these modes sometimes use roadways and sometimes use special facilities. According to the Alliance for Biking & Walking's *Benchmarking Reports* (AWB 2018), state departments of transportation spend on average about $3 annually per capita on active mode (walking and bicycling) facilities, about 0.5% of their budgets. The figure below illustrates regional transportation expenditures by mode, indicating that even in highly urbanized regions, highways receive the majority of funding. This suggests that the share of public resources invested in non-auto modes is significantly smaller than their demands.

Figure 2 **Regional Transportation Expenditures by Mode** (Deakin, et al. 2021)



Even very urban regions spend the majority of their transportation funds on roads, and little on active modes.

Local transportation budgets probably devote a larger share to sidewalks and paths, but still small amounts. For example, the U.S. Federal Highway Administration's *Nonmotorized Transportation Pilot Program* (FHWA 2014), invested about $100 per capita in pedestrian and cycling improvements in four typical communities over a four-year period, and a detailed engineering study estimated that improving all Albuquerque, New Mexico sidewalks to optimum standards would cost approximately $60 per capita or $6 annual per capita over a decade (Corning-Padilla and Rowangould 2020). This suggests that active transport facility costs range from $25-50 annual per user.

Parking Facilities and Subsidies

Detailed studies indicate that a typical urban community has three to six off-street parking spaces per vehicle, including one residential and two to five non-residential spaces (Chester, et al. 2015; Hoehne, et al. 2019; Scharnhorst 2018). Considering land, construction and operating costs, urban parking facilities annualized costs are typically $500-1,500 for surface spaces and twice as high for structured parking (Litman 2021). This suggests that off-street parking costs total $2,000-4,000 per vehicle; cities tend to have fewer but more expensive spaces, while suburbs have more but cheaper spaces. Walking requires no parking. About ten bicycles can park in the area required for one automobile, and bike parking often uses otherwise wasted spaces, so annual parking costs are estimated at $100 for bike, and $200 for e-bikes that require nearby electric outlets. Some transit users (perhaps 5%) regularly use park-and-ride facilities, so this cost is estimated to average $50 per transit user overall. About a third of parking facilities are residential, and so can be considered internal (users pay for them directly through rents and mortgages) and two thirds are external, financed through taxes and the prices of other goods.

Traffic Congestion

This refers to the delay that a vehicle imposes on other vehicles in traffic. There are many ways to measure these costs (Grant-Muller and Laird 2007). The Texas Transportation Institute's *Urban Mobility Report* (TTI 2021) estimated that in 2019, US congestion costs totaled $190 billion, or about $730 per vehicle-year, although other studies have lower estimates (Litman 2018). This analysis assumes that congestion costs average $500 per vehicle-year, and $600 for electric cars due to their higher mileage. Bicycles and bus travel can cause congestion, but generally much less than automobile travel under the same conditions (Schaefer, Figliozzi and Unnikrishnan 2020). Case studies indicate that shifts to walking and bicycling improvements generally reduce congestion (Rudolph 2017). This analysis assumes that pedestrians impose insignificant congestion cots, and bicyclists and transit passengers impose $50 per year in congestion costs.

Barrier Effect

Just as congestion costs reflect the delay that vehicles cause other vehicles, the barrier effect (also called *community severance*) refers to the delay that vehicle traffic causes to walking and bicycling. This includes delays when crossing streets, longer trips to reach safer crossing locations, and shifts from active to motorized modes (Anciaes, Jones and Mindell 2016). For example, as vehicle traffic increases in a neighborhood, parents often limit their children's walking and bicycling activity, and chauffeur them to local destinations. Although generally ignored in North America, some countries have standard methods for calculating barrier effect costs for transportation planning (DfT 2018; NZTA 2018). This analysis assumes that annual barrier effect costs average $50 per bus passenger, $200 for a conventional automobile, and $250 for an electric car, reflecting its higher annual mileage.

Crash Costs

This refers to crash damages, particularly external costs imposed on other road users. There are various ways to calculate these costs. Some estimates only include "economic costs," such as vehicle damage replacement, medical expenses and disability payments, while others also include non-monetary costs, often called "pain and suffering." A widely-cited National Highway Traffic Safety Administration study, *Economic and Societal Impact of Motor Vehicle Crashes*, estimated that in 2010, U.S. crash costs totaled $277 billion considering just economic costs, and $871 billion including non-market costs, equivalent to about $1,250-4,000 per motor vehicle in current dollars (Blincoe, et al. 2014). A portion of these costs are compensated by insurance, but a major portion is uncompensated and therefore external.

This analysis assumes that external crash costs average $1,000 annually for a fossil fuel automobile, and $1,200 for electric cars due to their higher annual mileage. Bicycling and public transit are assumed to impose $50 annual external costs. Walking is assumed to impose no external crash costs.

Noise and Air Pollution

Various studies have monetized motor vehicle noise and air pollution costs (Litman 2019). The results vary depending on the scope of impacts considered and methods used to measure impacts. For example, a major U.S. National Academy of Sciences study estimated that non-climate change emission costs average about $150 per vehicle-year (NRC 2009), and a major European study estimated that local air pollution costs average 0.0114 Euro and noise costs average 0.009 Euro per vehicle-kilometer, totaling about $400 per vehicle-year (CE Delft 2019). Carbon emission costs are generally estimated at $20-50 per metric ton. This study assumes that pollution costs currently average $500 per vehicle-year. Electric vehicles reduce these costs but electrical production emits various pollutants, and their operation produces particulate pollution and tire noise, which are estimated to average $150 annually (OECD 2020). Electric bikes are assumed to produce $10 per year pollution costs.

Resource Externalities

Resource externalities refers to uncompensated costs that result from the production of vehicle and their fuels, including government subsidies, environmental damages (such as environmental damages caused by oil wells and fracking), human risks from production and distribution (such as oil pipe line and truck explosions) plus macroeconomic costs of imports (ExternE 2015; NRC 2009). This reflects addition costs of consuming non-renewable resources and therefore the benefits of resource conservation, particularly in countries that devote large amounts of their export exchange to petroleum. This analysis assumes that fossil fuel vehicles have resource external costs averaging $200 annually, electric vehicle and public transit have $50 annual costs, and e-bikes have $5 annual costs.

Summary
Table 2 summarizes the estimated annual costs of various modes. It also indicates the assumed annual miles travelled by a typical full-time user. These costs can, of course, be pro-rated, for example, if people rely on a combination of modes.

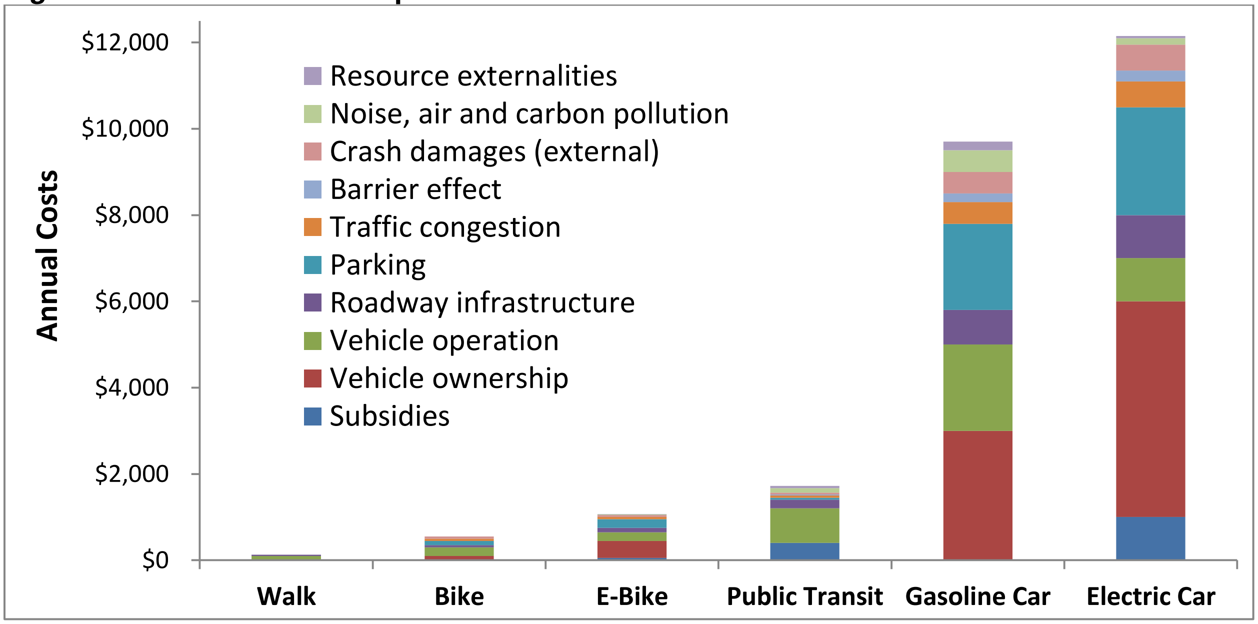
Table 2 **Annual Costs Per Full-Time User**

	Walk	Bike	E-Bike	Public Transit	Gasoline Car	Electric Car
Annual Miles	*1,000*	*2,000*	*3,000*	*4,000*	*10,000*	*12,000*
Subsidies	$0	$0	$50	$400	$0	$1,000
Vehicle ownership	$0	$100	$400	$0	$3,000	$5,000
Vehicle operation	$100	$200	$200	$800	$2,000	$1,000
Roadway infrastructure	$25	$50	$100	$200	$800	$1,000
Parking	$0	$100	$200	$50	$2,000	$2,500
Traffic congestion	$0	$50	$50	$50	$500	$500
Barrier effect	$0	$0	$0	$20	$200	$250
Crash damages (external)	$0	$50	$50	$50	$1,000	$1,200
Noise and air pollution	$0	$0	$10	$100	$500	$150
Resource externalities	$0	$0	$5	$50	$200	$50
Internal	*$113*	*$325*	*$650*	*$900*	*$5,400*	*$6,500*
External	*$13*	*$225*	*$415*	*$420*	*$4,200*	*$5,550*
Totals	***$125***	***$550***	***$1,065***	***$1,320***	***$9,600***	***$12,050***

This table summarizes annual costs of various travel modes.

Figure 3 illustrates these costs, measured per full time user-year.

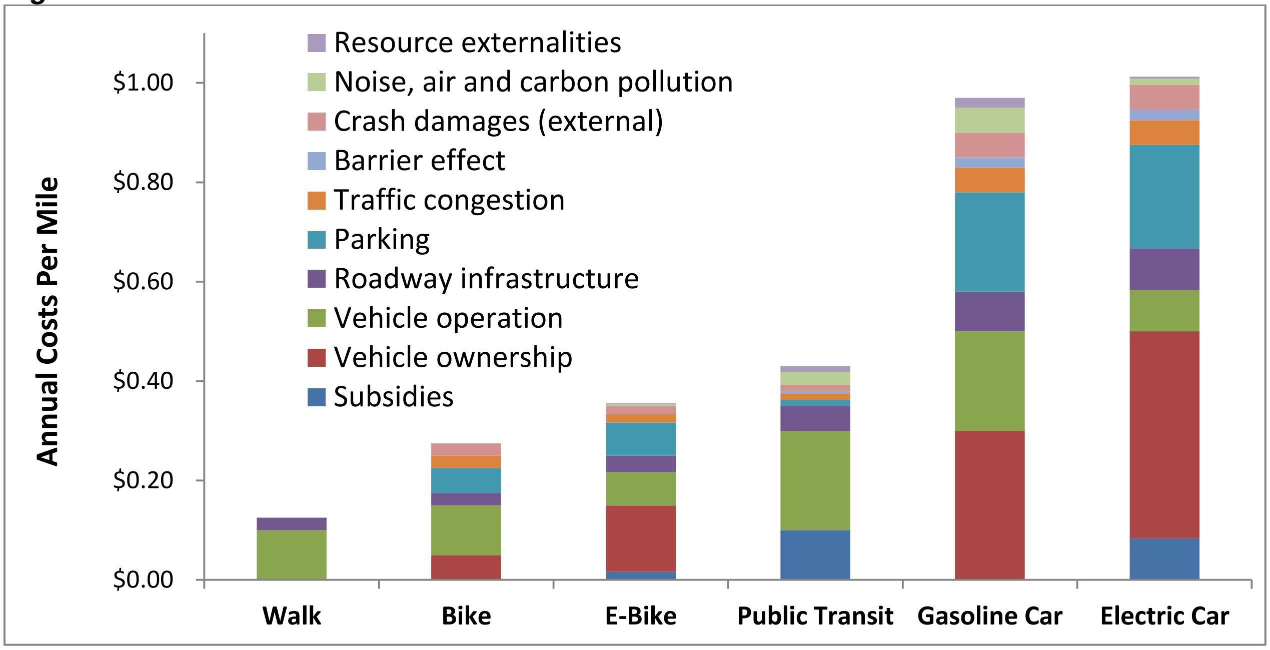
Figure 3 **Annual Costs per User**



This figure compares various costs of six travel modes, measured per year.

Figure 4 illustrates these costs measured per mile of travel.

Figure 4 **Costs Per Mile of Travel**



This figure compares various costs of six travel modes, measured per mile of travel.

Table 3 summarizes the estimated costs per mile of travel.

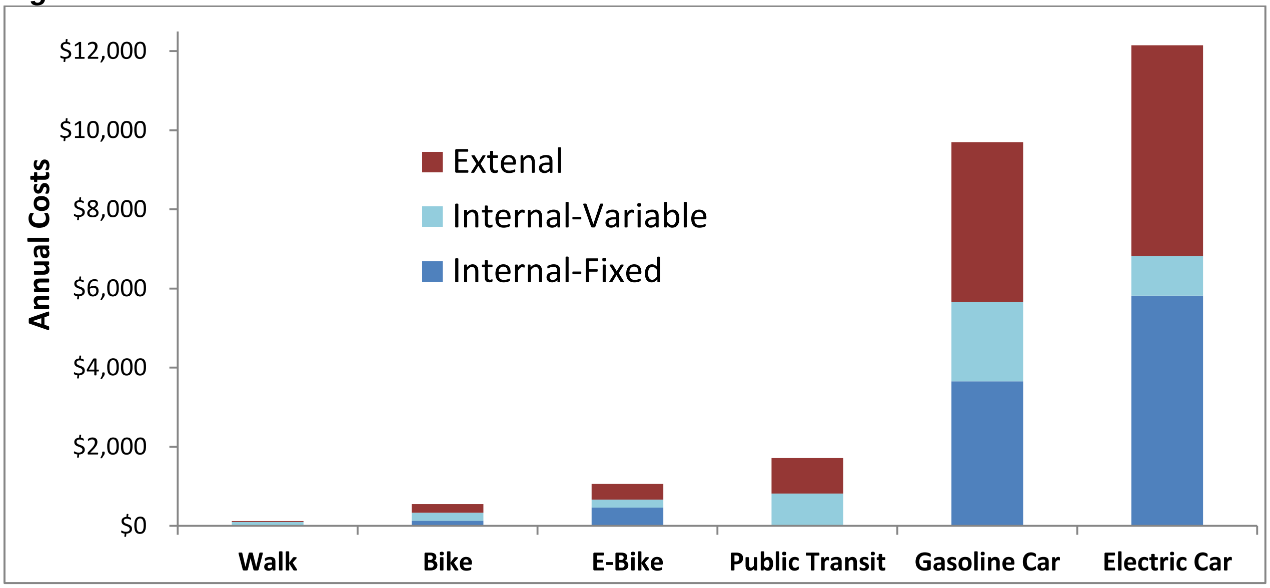
Table 3 **Costs Per Mile**

Costs	Walk	Bike	E-Bike	Public Transit	Gasoline Car	Electric Car
Subsidy	$0.000	$0.000	$0.017	$0.100	$0.000	$0.083
Vehicle ownership	$0.000	$0.050	$0.133	$0.000	$0.300	$0.417
Vehicle operating	$0.100	$0.100	$0.067	$0.200	$0.200	$0.083
Roadway infrastructure	$0.025	$0.025	$0.033	$0.050	$0.080	$0.083
Parking	$0.000	$0.050	$0.067	$0.013	$0.200	$0.208
Traffic congestion	$0.000	$0.025	$0.017	$0.013	$0.040	$0.042
Barrier effect	$0.000	$0.000	$0.000	$0.005	$0.020	$0.021
Crash damages (external)	$0.000	$0.025	$0.017	$0.013	$0.050	$0.050
Noise and air pollution	$0.000	$0.000	$0.003	$0.025	$0.050	$0.013
Resource externalities	$0.000	$0.000	$0.002	$0.013	$0.020	$0.004

This table summarizes per-mile costs of various travel modes.

Figure 5 compares the distribution of these costs by mode. Internal-variable costs, such as vehicle operation and fares, are roughly proportional to the amount that a person travels, and therefore tend to be most efficient and equitable. Internal-fixed costs, such as vehicle ownership and residential parking, are borne by users, but do not vary by use and so are inefficient since they encourage users to maximize their vehicle travel in order to get their money’s worth from those expenditures. External costs are both inefficient and unfair, particularly when expensive modes used by higher-income travellers impose external costs on disadvantaged groups, such as when motorists impose delay, risk or pollution exposure on lower-income walkers, bikers and public transit passengers.

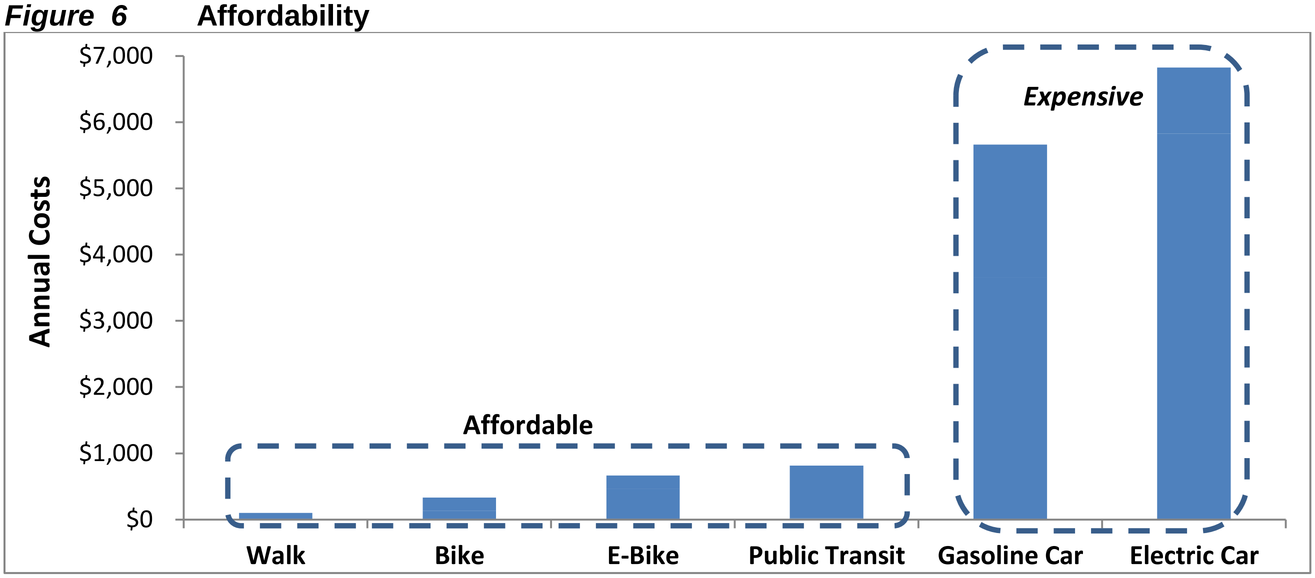
Figure 5 **Cost Distribution**



This figure compares the cost distribution of various modes, assuming that vehicle expenses, plus a third of parking costs, and half of gasoline cars' roadway costs (because they pay fuel taxes) are internal.

Figure 6 compares total user costs of these modes. Walking, bicycling, e-bikes and public transit are far cheaper, by an order of magnitude, than automobile travel.

Figure 6 **Affordability**



Walking, bicycling, e-bikes and public transit are much cheaper than automobile travel.

Conclusions

Transportation imposes many costs, including direct user expenses, plus many indirect costs imposed on other community members. Transportation is one of the largest household expenses, including some often-overlooked costs such as the portion of housing costs devoted to driveways and garages, plus additional local taxes and higher prices for commercial goods required to pay for off-street parking. Vehicle travel also imposes various external traffic costs including congestion, crash risk and pollution imposed on other community members. These costs vary significantly depending on mode and travel conditions. Walking, bicycling, e-bikes and public transit are affordable and resource-efficient; they have lower user expenses, require less space for travel and parking, impose less risk, consume less energy and produce less pollution per mile of travel, and since motorists travel far more annual miles than most people who rely on non-auto modes, motorists impose more total annual costs. As a result, people who drive less than average tend to overpay their transportation costs and subsidize people who drive more than average. This is inefficient and unfair, and since annual vehicle travel tends to increase with income, is regressive; it results in lower-income households subsidizing the transportation costs of higher income households.

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