



## Transportation Cost and Benefit Analysis

### *Techniques, Estimates and Implications*

Second Edition (2009)

~~~~~  
**Executive Summary**

Full report available at [www.vtpi.org/tca](http://www.vtpi.org/tca)

~~~~~  
4 January 2009

By

Todd Alexander Litman

*Victoria Transport Policy Institute*

With Eric Doherty

#### **Abstract**

This 500+ page document is a comprehensive study of transportation benefit and costing, and a guidebook for applying this information. It includes detailed analysis of various transport costs and benefits. These impacts are described in detail and categorized by various attributes: whether they are internal or external, fixed or variable, market or nonmarket. Using the best available data, it provides monetized estimates of twenty three costs for eleven travel modes under three travel conditions.

This document is unique in several important ways. It is one of the most comprehensive studies of its kind, including many often-overlooked impacts. It is the only transport cost study regularly updated as new information becomes available. It explains economic concepts and evaluation techniques. It provides costs values in a format designed to help users easily apply this information to policy analysis and planning situations. It includes a spreadsheet that automates cost analysis. It discusses the implications and applications of analysis results. It provides extensive references, many available through the Internet, so users can obtain more detailed information as needed.

This study indicates that on average about a third of automobile costs are external and about a quarter are internal but fixed. Fuel efficient and alternative fuel vehicles tend to have somewhat lower external costs. Transit tends to have lower total costs under urban-peak conditions. Ridesharing tends to have the lowest marginal costs. Motorcycles tend to have relatively high costs due to their high crash risk. Nonmotorized modes (walking and cycling) have minimal external costs. This study describes various policy and planning reforms that can help increase economic efficiency and equity.

## Introduction

Smart consumers investigate all costs and benefits before making major purchase decisions. Prior to buying a car you want accurate information on its fuel, maintenance, repair and insurance costs. Similarly, before buying a train or airline ticket you want to know about all fees and taxes, and the ease of schedule changes. You also want information on each option’s reliability, comfort and safety. Just as consumers need accurate and comprehensive information when making personal travel decisions, communities need accurate and comprehensive information on all significant impacts when making transport policy and planning decisions.

Transportation policy and planning decisions often involve tradeoffs between conflicting objectives. For example, strategies to increase vehicle travel speeds can increase crash risk and degrade walking conditions. This guidebook provides a framework for evaluating and rationalizing such decisions. It examines how benefits and costs vary for different travel modes and conditions. It supports more comprehensive planning analysis by providing benefit and cost information in a convenient and flexible format.

## Cost Analysis Framework

Table 1 lists the twenty-three transportation costs evaluated in this report.

**Table 1**      **Transport Cost Categories**

Cost	Description
Vehicle Ownership	Fixed costs of owning a vehicle.
Vehicle Operation	Variable vehicle costs, including fuel, oil, tires, tolls and short-term parking fees.
Operating Subsidies	Financial subsidies for public transit services.
Travel Time	The value of time used for travel.
Internal Crash	Crash costs borne directly by travelers.
External Crash	Crash costs a traveler imposes on others.
Internal Activity Benefits	Health benefits of active transportation to travelers (a cost where foregone).
External Activity Benefits	Health benefits of active transportation to society (a cost where foregone).
Internal Parking	Off-street residential parking and long-term leased parking paid by users.
External Parking	Off-street parking costs not borne directly by users.
Congestion	Congestion costs imposed on other road users.
Road Facilities	Roadway facility construction and operating expenses not paid by user fees.
Land Value	The value of land used in public road rights-of-way.
Traffic Services	Costs of providing traffic services such as traffic policing, and emergency services.
Transport Diversity	The value to society of a diverse transport system, particularly for non-drivers.
Air Pollution	Costs of vehicle air pollution emissions.
Greenhouse Gas Pollution	Lifecycle costs of greenhouse gases that contribute to climate change.
Noise	Costs of vehicle noise pollution emissions.
Resource Externalities	External costs of resource consumption, particularly petroleum.
Barrier Effect	Delays that roads and traffic cause to nonmotorized travel.
Land Use Impacts	Increased costs of sprawled, automobile-oriented land use.
Water Pollution	Water pollution and hydrologic impacts caused by transport facilities and vehicles.
Waste	External costs associated with disposal of vehicle wastes.

*This table defines the 23 transport cost categories evaluated in this study.*

Table 2 categorizes these costs according to whether they are *internal* (users bear them directly) or *external* (imposed on non-users), *variable* (related to the amount of travel) or *fixed*, and *market* (involve goods regularly traded in competitive markets) or *non-market*.

**Table 2 Transportation Cost Categories**

Cost	Internal/ External	Variable/ Fixed	Market/ Non-Market	Cost	Internal/ External	Variable/ Fixed	Market/ Non-Market
1. Vehicle ownership	Internal	Fixed	Market	13. Roadway land value	External	Fixed	Market
2. Vehicle operation	Internal	Variable	Market	14. Municipal services	External	Variable	Market
3. Operating subsidies	External	Fixed	Market	15. Equity & option value	External	Variable	N-M
4. Travel time	Internal	Variable	N-M	16. Air pollution	External	Variable	N-M
5. Internal crash	Internal	Variable	N-M	17. Greenhouse gas	External	Variable	Mixed
6. External crash	External	Variable	Mixed	18. Noise	External	Variable	N-M
7. Internal activity*	Internal	Variable	Mixed	19. Resource consumption	External	Variable	Mixed
8. External activity*	External	Variable	Mixed	20. Barrier effect	External	Variable	N-M
9. Internal parking	Internal	Fixed	Market	21. Land use impacts	External	Fixed	Mixed
10. External parking	External	Variable	Market	22. Water pollution	External	Variable	N-M
11. Congestion	External	Variable	Mixed	23. Waste disposal	External	Variable	N-M
12. Road facilities	External	Variable	Market				

*This table lists the 23 costs identified in the study and indicates how they are distributed.*

Table 3 describes the eleven transport modes evaluated in this study. Monetized (measured in monetary values) estimates are developed of each cost for each mode under three travel conditions (urban-peak, urban off-peak and rural) in 2007 U.S. dollars per vehicle-mile. These cost estimates are based on extensive research, including the results of previous studies updated to reflect inflation and other changes, and some original analysis. This guidebook includes a chapter concerning each cost category, with detailed analysis and extensive references.

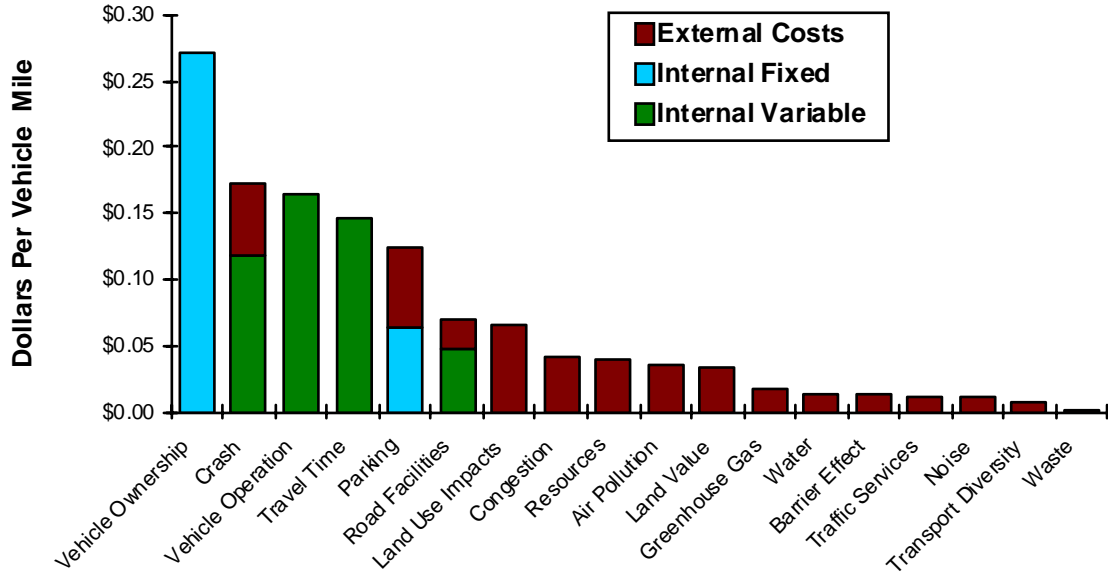
**Table 3 Transport Modes**

Mode	Description
Average Automobile	A medium sized car that averages 21 mpg overall (16 mpg city driving, 24 mph highway driving), averaging 1.5 overall and 1.1 Urban-Peak occupancy.
Compact (Fuel Efficient) Car	A small four passenger car that averages 40 mpg overall (34 mpg city driving, 46 mpg highway driving).
Electric Car	A medium size electric car that averages 0.5 kWh per mile fuel efficiency.
Van or Light Truck	A 14 passenger van or light truck that averages 15 mpg overall (14 mpg city and 20 mph highway driving). Occupancy is same as an automobile.
Rideshare Passenger.	The incremental cost of an additional passenger.
Diesel Bus	A 40 foot bus with 25 peak and 8 Off-Peak passengers, averaging 4.0 mpg.
Electric Bus/Trolley	A 65 passenger bus or trolley with 30 peak and 10 off-peak passengers, averaging 6.5 mpg energy consumption equivalent.
Motorcycle	A medium size motorcycle 45 mpg urban and 55 mph rural average fuel efficiency.
Bicycle	A moderate priced bicycle ridden an average of 10 mph.
Walk	A person walking an average of 3 mph.
Telework	Two 11 mile commute trips avoided when employees work from home.

*This table describes the eleven transport modes evaluated in this study.*

Figure 1 illustrates the costs for an Average Car ranked by magnitude, with internal and external components combined. This shows that the largest categories of costs tend to be internal, including vehicle ownership, travel time, vehicle operation and crash risk borne directly by individual motorists. External costs tend to be smaller, and so are easy to overlook, but numerous, so their aggregate value tends to be significant.

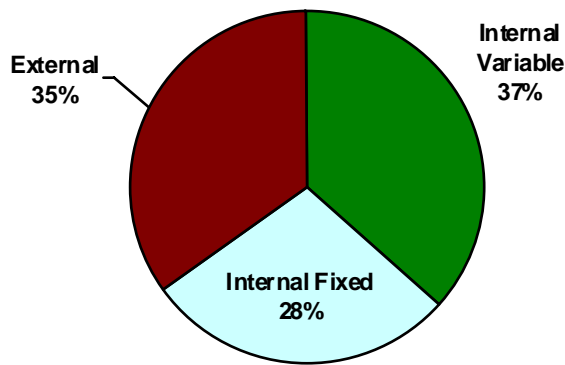
**Figure 1 Average Automobile Costs**



This figure shows Average Car costs per vehicle mile, ranked by magnitude. External costs tend to be small but are numerous.

Figure 2 shows the distribution of costs aggregated. About a third of total costs are External and about a quarter are Internal-Fixed, leaving less than half Internal-Variable, indicating significant underpricing (prices are significantly below total costs).

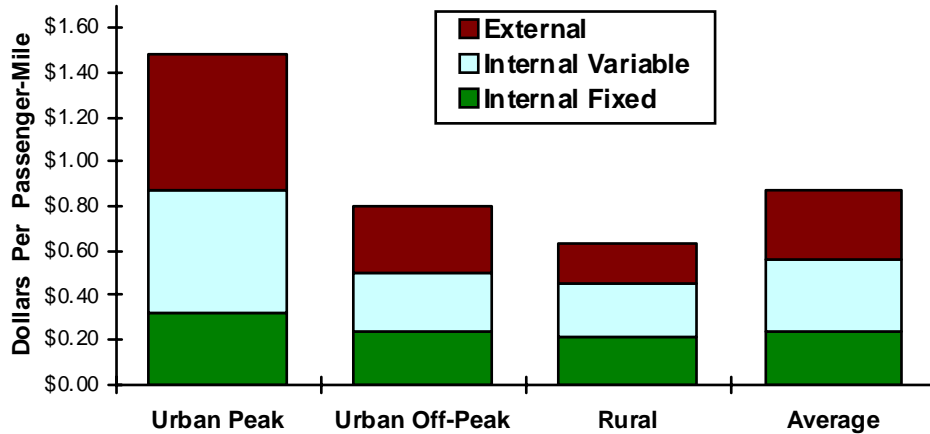
**Figure 2 Average Car Cost Distribution**



This figure illustrates the aggregate distribution of costs for an average car. About 60% of total vehicle costs are either External or Internal-Fixed.

Figure 3 shows the distribution of costs per *passenger-mile*, calculated by dividing costs per vehicle-mile by average vehicle occupancy. Urban-peak travel has relatively high costs because peak-period vehicle occupancy tends to be lower than average (1.1 passengers per vehicle compared with 1.42 for other travel conditions).

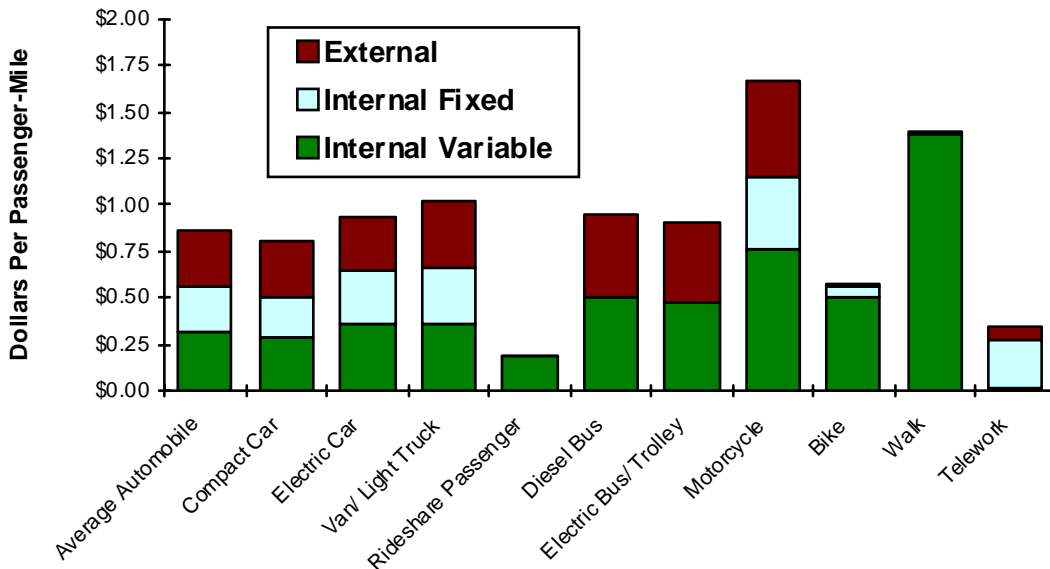
**Figure 3 Average Car Costs Per Passenger-Mile**



This figure illustrates how aggregate costs per passenger-mile vary by travel conditions, taking into account differences in vehicle occupancy. Urban-peak vehicle occupancy is low; therefore urban peak passenger mile costs are high compared to the other categories.

Figure 4 compares costs per passenger-mile for each of the eleven modes. Both the magnitude and the distribution of costs vary significantly between modes.

**Figure 4 Cost Distribution by Mode**



This graph shows the cost distribution of each mode. Transit costs are based on average U.S. ridership levels and would be lower in areas with higher ridership rates.

## **Implications**

This analysis indicates that a major portion of transportation costs are external, fixed and non-market. On average, each dollar spent on vehicle operating expenses imposes about \$2.55 in total costs to society. External and fixed costs represent underpricing. This cost profile is inequitable and leads to economically excessive motor vehicle travel that exacerbates various economic, environmental and social problems.

Non-market costs tend to be undervalued in transportation planning. These costs are significant in magnitude compared with impacts normally considered. Failure to consider these costs can lead to decisions that result in negative net benefits. For example, society is overall worse off if a roadway expansion saves motorists 5¢ per mile in average travel time costs but imposes 10¢ per mile on average in additional economic and environmental costs.

## **Applications**

Comprehensive economic analysis can be used in many planning applications:

- Transportation policy analysis. Establish strategic goals and objectives taking into account all impacts, including those that are indirect and long-term.
- Transportation pricing. Develop more efficient prices that reflect the full costs.
- Investment policies. Account for all impacts when determining which transport investments are overall optimal.
- Transportation equity analysis. Consider all impacts, including those that are indirect and non-market, when evaluating equity.
- Transportation Demand Management analysis. Consider all impacts when evaluating strategies that reduce total vehicle travel and encourage use of alternative modes.

## **Conclusions**

If you ask people what it costs to drive they typically mention vehicle operating expenses, which average approximately 16¢ per mile for a typical car. Some may also include a portion of vehicle ownership costs, which average about 27¢ per mile. A few may also mention the value of their travel time and accident risk. These, however, are only a portion of total costs. The full cost of driving includes these internal costs plus several external costs. Total costs range from about \$0.94 per vehicle mile for rural driving to \$1.64 for urban peak driving. Of course there is considerable variation in the cost of any specific trip, but these estimates, and variations for different travel modes and specific conditions, provide a reasonable basis for analyzing true transport costs.

This price structure is inefficient. Vehicle owners have little incentive to limit driving to trips in which benefits exceed total costs, resulting in economically excessive vehicle travel that reduces transport system performance. Problems such as traffic congestion, traffic risk, and pollution are virtually unavoidable with current pricing.

This price structure is horizontally inequitable because people must bear significant costs imposed by others. It is vertically inequitable because it tends to benefit the wealthy and reduces travel options for non-drivers. Whether price increases are regressive depends on how revenues are used. Actions that increase travel options for non-drivers, such as better transit service, improvements to the pedestrian and bicycling environment, and reduced urban sprawl, tend to be overall progressive because they benefit disadvantaged people.

There is no single solution to our current transportation problems. Neither, improved bicycling and walking facilities, increased public transit service, “smart” highways, nor less polluting vehicles alone can solve our transport problems while driving is so underpriced. More efficient pricing is essential to solving transportation problems. Changes in planning, land use, and infrastructure investments are also needed. An efficient and equitable transportation system offers users efficient mobility options and incentives to use each mode for what it does best.

Conventional planning tends to evaluate transportation performance based on travel distance, which favors mobility over accessibility, faster modes over slower modes, and speed over comfort. For example, conventional transport economic analysis can calculate the monetized value of travel time savings from highway expansion that increases travel speeds, but cannot provide monetized benefits from increasing local services, improving children’s ability to walk and cycle to schools, or from increasing the convenience and comfort of public transit travel, for example, by providing real-time bus arrival information or more comfortable transit stop waiting conditions.

Since most urban trips are relatively short (less than 5 miles), there is a “transportation gap” caused by overemphasis on long-distance travel and too little attention to bicycling, local transit, and low powered vehicles. This creates a self-fulfilling prophecy of increased driving, automobile dependency, inequity and sprawl. Electric cars and other alternative fuels reduce some external costs, particularly urban air pollution, noise, and petroleum externalities, but do little to reduce other problems such as accident risk, congestion, and parking subsidies.

Traffic impacts on community livability deserve special attention. The road system is a valuable public asset. In addition to accommodating vehicle travel streets define a community’s character, accommodate walking and cycling, and allow community interactions. Motor vehicle traffic tends to degrade these functions. New urban neighborhood design and traffic calming programs can reduce traffic impacts and return streets to multi-function use. Implementing these improvements requires changes to transport planning and funding practices.

More research is needed to better estimate transportation costs under various conditions and locations. Transport equity and diversity appear to be significant values which deserve more research. Decision-makers need better information on consumer demands, such as the value people place on improved travel convenience and comfort. Research is also needed to evaluate the synergistic effects of combined planning decisions.