**TOPIC 18**
ENVIRONMENT AND
SUSTAINABLE MOBILITY

# ASSESSMENT OF THE ACTUAL COST OF AUTOMOBILE TRANSPORT

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## Abstract

This paper assesses the social cost of automobile travel in the United States. Beyond private costs, society at large is burdened with the cost of paying for infrastructure maintenance, highway services, wasted fuel, pollution, accidents and congestion costs for travel delays. These social costs totalled to 6 cents per kilometre (9.6 cents/mile).

## INTRODUCTION

The traffic problem of congestion, especially during peak hours, continues to worsen on a daily basis. The increase in travel demand has led to high-volume traffic and slower commutes at peak times. For major cities, this scenario often encompasses the entire metropolitan area. Modifying automobile use through pricing schemes such as efficient tolls is one congestion alleviation technique that shows promise. Efficient tolls are "tolls which would ensure that the price paid by the roadway user is equal to the increment of social and private cost resulting from the highway use" (Hanson 1992). Economists, have long argued that for industries with large fixed facilities and variable demand, pricing can help spread demand more evenly by increasing efficient use of existing facilities and reducing the need for expensive capacity additions. Road pricing schemes recommend that tolls or user charges be implemented on congested roadways to improve traffic flows.

The logic behind this recommendation is because drivers only consider the private cost of automobile travel in deciding to "buy" a trip. In other words, individual highway users decide whether to use a highway facility by weighing the costs they will bear against the benefits to themselves. If the benefits of the user exceed or are equal to the costs to be borne by the user, the user will decide to use the facility (Khisty 1992). However, driving also imposes social costs upon society. These social costs include an increase in travel time for all commuters, excessive fuel consumption due to uneven traffic flow, air and noise pollution, and an increase in the probability of accidents. Therefore, driving costs should include the social costs so that the driver can accurately evaluate the "actual cost" of making a trip.

## SOCIAL COSTS

As suggested, drivers should be held accountable for the social costs they create. Social costs may be defined as those costs of an economic activity borne in some way by society, rather than by those involved in it as producers or users (Ullmann 1983). These costs represent the damage imposed on others as a result of taking the trip; the wear and tear on the infrastructure; congestion; and possible environmental impacts such as noise, air and water pollution (Downs 1992). The realization of these costs will discourage the unnecessary use of any roadway, and encourage the planned decision of making a trip.

Road pricing that includes social costs can be classified into three categories to reflect the different objectives that lie behind their respective charges.

1. *Infrastructure Costs*: These charges are to raise money for new road construction and to provide for the timely and quality maintenance of highly traveled roadways. To be effective, these revenues should be used to finance public transportation improvements. Improved transit facilities provide a comparable alternative for the automobile trip. The better the public system, the greater the rider attraction to it. Infrastructure costs charge for road construction, maintenance, and highway services, that are not borne by the user.

2. *Environment Costs*: These fees help to reduce traffic levels to achieve environmental benefits like reductions in pollution, noise levels, and accidents. Environment costs include all costs associated with accidents, air pollution, water pollution, noise pollution, litter, loss of aesthetics, and the impact on unique resources.

3. *Congestion Costs*: These charges are necessary to regulate demand directly through the price mechanism, and by that, reduce traffic congestion. Congestion costs account for travel time delays, and wasted energy from excessive fuel consumption. However, these costs are already borne by the user and therefore a marginal-cost user charge is applied to cover the costs caused by adding an additional vehicle to the existing traffic stream. This ensures that the independent decision by a user considers the interests of all (Small et al. 1989).

In our road pricing proposal, the infrastructure costs and the environment costs are average costs charged to motorists at all times. The marginal costs due to congestion, are additional costs charged during peak-hours or whenever congestion is prevalent.

## PCE'S AND ESAL'S

To design efficient user charges, two dimensions of the highway system have to be considered. The first, is the volume of vehicles that can be moved over the system in a given time. For this, the standard unit of measurement is the passenger car equivalent (PCE). Each vehicle takes up some effective amount of space, and competition for this space results in congestion. The other dimension is the vehicular weight, and the unit of measure is the equivalent single 18,000 pound axle load (ESAL). Durability and the duration of maintenance repairs are related to axle weights. Thus the output of the highway system is a combination of PCEs and ESALs (Lee 1982).

## TECHNOLOGY

The outcome of any toll collection scheme, depends in part on whether vehicles can be charged road-user fees without disrupting traffic flows. The latest technique devised to deal with this issue is called automatic vehicle identification (AVI). AVI technology can handle 1,200 to 1,800 vehicles per lane-hour compared to current toll collection methods that only service 300 to 500 vehicles in the same time. Electronic transponders are placed in or on each vehicle and electronic sensors are buried in the road. Computers are used to track vehicle movements, calculate charges, and mail electronic bills to vehicle owners. AVI now makes it possible to collect differing amounts during different traffic levels, efficiently and conveniently.

## METHODOLOGY

To calculate the charges (toll) for a road pricing scheme, we choose the urban highway for the following two reasons. First, the urban highway with its limited access, allows for the installation of "electronic toll booths" at all entry and exit ramps. Second, this road type is subject to all the social cost categories discussed until now. Costs are calculated for this particular road type wherever existing data permits. However, for a few categories, we use costs calculated on a national scale due to the lack of good data.

For simplicity we consider traffic on the urban highway as either passenger vehicles or trucks. Passenger vehicles are 75% of the traffic with trucks making up the remaining 25%. Using the passenger car-equivalent (PCE) and considering all trucks as two PCEs, the modified traffic distribution of cars and trucks is 70% and 30% respectively. Looking at each social cost category listed in Table 1, concurrent studies help us decide the costs attributable to each of the two vehicle types. For example, trucks are responsible for 80% of maintenance costs. This reduces considerably, the contribution made by automobiles to 20%. By examining both cars and trucks, we can then recalculate the charge levied on automobile drivers. For maintenance costs, the new automobile charge is only 20% of the urban highway maintenance cost.

**Table 1 Summary of the social costs of automobile travel on urban highways**

| Social costs | National costs/km a | Urban highway costs/km b | % not paid by user c | Adjusted urban highway costs/km d=bc/100 | Auto contribution (%)** e | Truck contribution (%)** f=100-e | Auto costs cents/km g=de/100 |
|---|---|---|---|---|---|---|---|
| *Infrastructure costs* | | | | | | | |
| Capital outlays | 1.09 | 2.17 | 41 | 0.89 | 55 | 45 | 0.49 |
| Maintenance | 0.64 | 1.27 | 41 | 0.52 | 20 | 80 | 0.10 |
| Highway services | 0.19* | 0.19 | 41 | 0.08 | 70 | 30 | 0.06 |
| Administration | 0.21* | 0.21 | 41 | 0.09 | 70 | 30 | 0.06 |
| Debt retirement | 0.23* | 0.23 | 41 | 0.09 | 70 | 30 | 0.06 |
| *Environment costs* | | | | | | | |
| Accidents | 4.00 | 2.91 | 44 | 1.30 | 70 | 30 | 0.91 |
| Travel delay (accidents) | 0.11 | 0.08 | 100 | 0.08 | 70 | 30 | 0.06 |
| Air pollution | 0.70* | 0.70 | 100 | 0.70 | 70 | 30 | 0.49 |
| Noise pollution | na | 0.29 | 100 | 0.29 | 25 | 75 | 0.07 |
| Vibration | 0.34* | 0.34 | 100 | 0.34 | 0 | 100 | 0.00 |
| Litter/unique resources | tbd | tbd | 100 | tbd | 70 | 30 | tbd |
| Water and soil pollution | tbd | tbd | 100 | tbd | 70 | 30 | tbd |
| **Social Costs (non-peak)** | | | | | | | **2.30** |
| *Congestion costs* (during peak) | | | | | | | |
| Travel delay (congestion) | | 8.00 | MC | 8.00 | 70 | 30 | 5.60 |
| Wasted energy | | 1.10 | MC | 1.10 | 70 | 30 | 0.77 |
| **Social Costs (peak)** | | | | | | | **8.67** |

*Notes*
* National costs used for Urban Highway
** from concurrent studies using transportation data and statistics
MC Marginal Costs specific for Eisenhower Expressway
na not available
tbd to be determined

## INFRASTRUCTURE COSTS

In assessing the actual cost of automobile transport, infrastructure costs play a significant part and account for a large portion of the costs incurred. Currently, taxpayers subsidize these costs and measures have to be taken to correct this practice. This nation's road system is among the world's most impressive public investments. Encompassing nearly 6.4 million kilometers (4 million miles), the system of federal, state, county, and local roads handles almost 3.6 trillion vehicle-kilometers (2.3 trillion vehicle-miles) each year.

Urban highways provide for roughly 700 billion veh-km (440 billion veh-mi) per year. Federal, state and local governments pay the annual costs of building and maintaining these highways and roads. In 1992, these governments spent close to $39 billion in capital outlays for this nation's infrastructure. These massive expenditures covered the costs of land acquisitions, right-of-way, construction engineering, construction, reconstruction, and installation of traffic service facilities on roadways. In addition, $23 billion were spent on maintenance and traffic services, $7 billion on highway law enforcement and safety services, $7.7 billion on administration and research, and $8 billion on interest and debt retirement (Highway Statistics 1992). Adding these expenditures, we find that a staggering $85 billion is the annual investment in our infrastructure.

Of the funds raised for highways, 59% came from federal and state highway user related taxes (gasoline taxes, registration and license fees) and tolls. The remaining *41%* of the costs were borne by non-users in the form of local property taxes, general funds, investment income and bond issue proceeds (Highway Statistics 1992).

### Capital outlays and maintenance costs

Our government spends roughly $39 billion on capital outlays and $23 billion on maintenance. Trucks are largely responsible for maintenance costs since the equivalence factor for an axle (ESAL) rises very steeply with its load—roughly as its third power (Small et al. 1989). The rear axle of a typical 13,200 kilogram (thirteen-ton) van causes over 1,000 times as much structural damage as that of a car. To cover the subsidized portion of these costs (41%), a charge of *0.5 cents/veh-km* (*1.24 cents/veh-mi*) for capital outlays and *0.26 cents/veh-km* (*1.42 cents/veh-mi*) for maintenance has to be exacted. For urban highways the charges are *0.89 cents/veh-km* (*1.42 cents/veh-mi*) and *0.52 cents/veh-km* (*0.83 cents/veh-mi*) respectively.

### Highway services

Highway services provided for motorists include highway patrols, traffic management, parking enforcement and emergency responses to traffic accidents. Police, firefighters, paramedics, and Emergency Traffic Patrols (minutemen), are all part of emergency teams that respond immediately to all calls of distress. Other benefits provided by the state highway authorities primarily for highway users are; investigations of vehicle accidents, traffic reports, and routine maintenance. High-volume, high-speed roadways cannot operate efficiently without the aid provided by highway services. In urban areas surrounding large metropolitan cities the situation is of greater concern. A single peak hour incident coupled with congestion could bring traffic to a standstill for long periods. More important are the safety implications. The immediate response to an emergency situation, can sometimes be the difference between life and death. State and federal highway departments supervise these services and incur substantial administrative costs. Most of these costs are currently subsidized (41%) by the government (Highway Statistics 1992), but efficient tolls should charge highway users for the benefit they receive from these services. In 1992, this nation spent $7 billion on police and safety services creating a driver fee of *0.19 cents/veh-km* (*0.31 cents /veh-mi*). Government subsidization of these services should be replaced with this fee in recognition of this necessary and "good value" component of highway travel.

### Administration and research / debt retirement costs

These costs are necessary to administer a State or local highway program. Most often these costs include general overhead, engineering, highway planning and research, litigation and publications. Government spent close to $7.7 billion on administration and research for 1992. The charge (41%) per vehicle-km amounts to *0.09 cents/veh-km* (*0.14 cents/veh-mi*). For debt retirement the $8 billion cost adds another *0.09 cents/veh-km* (*0.14 cents/veh-mi*).

## ENVIRONMENT COSTS

There are growing demands for sustainable environments all over the world and therefore environment costs are gaining corresponding attention as we become aware of environmental problems and issues, at all geographical and temporal scales. Transportation has many undesirable impacts on the environment, and highway vehicles are largely responsible for these problems.

The fuels that power vehicles, produce emissions that damage our environment, affect human health, and contribute to global climate change. Drivers must realize that the higher the emissions rate, the more sensitive and numerous the receivers are, and the higher are the social costs of a vehicle trip.

## Accident costs

Motor vehicles dominate accident statistics, with these vehicles involved in nearly 93 percent of all transportation fatalities. In 1992, 39,235 people were killed, over 3.4 million drivers were injured, and 30 million vehicles were damaged in motor vehicle crashes. On the urban highway there were 3,030 fatalities and 325,600 injuries (Transportation Statistics Annual Report 1994).

Death, injury and property damage caused by these crashes are the major reason for personal suffering, and financial loss to the victims and to society. Societal costs of automotive accidents include productivity losses, losses in household production, medical costs, emergency services, insurance administration costs, legal and court costs, employer costs, property damage and travel delay costs. In 1992, each fatality cost $725,000 and $147.5 billion was the total economic cost of accidents. Medical costs were $14.9 billion, property damage costs were $49.0 billion, lost productivity costs were $54.2 billion, and other costs were $29.4 billion (The Economic Cost of Highway Crashes 1990). Some costs incurred in crashes are paid by the individuals involved, while other costs are paid for by society. To calculate the accident costs that need to be charged as part of an efficient toll, we select only the costs borne by the government and by others not directly involved in an accident. Of the total bill, the government pays for 8.4% while the others pay 4.7% for a total of 13.1%.

If victims of accidents should not have to pay for uninsured costs from their own pockets, then we collect an additional 30.7% for a total of nearly *44%*. Insurers pay the remaining 56 percent (The Economic Cost of Highway Crashes 1990). Given that the annual costs of accidents are $143.5 billion, the portion (44%) to be borne by motorists amounts to $63.1 billion or *1.8 cents/veh-km* (*2.8 cents/veh-mi*). For urban highways the drivers' share of accident costs ($20.4 billion x 44%) are *1.3 cents/veh-km* (*2.0 cents/veh-mi*).

## Travel delays (accidents)

Travel delays that result from accidents, add to the prevailing delays experienced due to congestion and only worsen the situation. Studies show that congestion increases the chances for accidents, as frustrated drivers and their vehicles compete for scarce space (Lee 1982). The result is a vicious cycle that leads to increased delays. The 1992 costs of accident-related delays were $4 billion annually (The Economic Cost of Highway Crashes 1990), and amount to *0.11 cents/veh-km* (*0.18 cents/veh-mi*). On urban highways the delay costs are $557 million or *0.08 cents/veh-km* (*0.13 cents/veh-mi*).

## Air pollution costs

Automobile engines produce a variety of exhaust emissions that include carbon monoxide (CO), carbon dioxide ($CO_2$), nitrogen oxides ($NO_X$), sulfur oxides ($SO_X$), hydrocarbons (HC) or nonmethane volatile organic compounds (VOC), total particulate matter (TP), and lead. Transportation statistics for 1992, attribute the following percentages for each pollutant to highway vehicles; Carbon Monoxide (58.2%), Nitrogen Oxides (28.7%), Sulfur Oxides (2.9%), Hydrocarbons or Volatile Organic Compounds (22.6%), Total Particulate Matter (17.8%), and Lead (28.8%).

Mark French (1988) estimates the costs of ill health, lost productivity and reduced agricultural revenues due to the generation of ozone by exhaust fumes at 3.5 to 11 cents per gallon with a point estimate of six cents ($1987). These estimates do not include the costs of acid rain, chronic health problems, carbon monoxide health impacts, and forest damage from low altitude ozone. Updating these values for 1992, puts the damages at $9.5 billion per year. The Congressional Office of Technology Assessment, estimates the economic health benefits of meeting the prescribed ozone standard at $0.5 to $4 billion per year (1989). Researchers at the University of California, Davis, estimated the damage due to air pollution caused by exhaust emissions at $10 to $200 billion per year (Sperling and DeLuchi 1989). Their estimates included illnesses, premature death, reduced agricultural productivity, property damage and reduced visibility. The wide range in the estimate of air pollution costs was attributed to the uncertainty in the number of deaths and illnesses, and the difficulty in evaluating the monetary value of human health and life. MacKenzie (1994) uses what he calls a conservative estimate of $10 billion in his analysis. Another study by Lee (1982), estimates that the costs of air pollution due to motor vehicles on an average are 0.7 cents/km (1.1 cents/mi) in urban areas. The same study cautions that there are wide variations depending on the area and the particular meteorological conditions. Ketcham (1991) reports $30 billion for health care costs alone due to transportation air pollution. Highway vehicles account for 80 percent of the air pollution costs by the transportation sector. Using Ketcham's figures, the air pollution cost amounts to $25 billion for 1992. To cover this cost, the driver will have to pay *0.7 cents/veh-km (1.1 cents/veh-mi)*.

## Noise costs

Noise generated by traffic is an environmental problem that affects society, especially to those who live close to our nation's highways. Although the damage caused by noise is not as severe as that of air pollution, nonetheless, citizens are more annoyed by it (Job 1991). The social cost of noise pollution is yet another cost not borne by drivers. Some costs associated with noise are due to reduction in land and housing values, general annoyance, sleep disturbance, headaches, nervousness, stress and fatigue (Bullington 1974). Based on total travel in urban areas in 1989, noise damage from cars and trucks to property damage in urban areas is estimated at $9 billion per year (French 1991). Trucks are responsible for about 85 percent of this damage (Ketcham 1991). Noise barriers, which are considered the most effective and least expensive of noise abatement measures, typically cost $625,000/km ($1 million/mi).

For urban highways, the cost of noise pollution adds to $21 billion by providing noise barriers for the roughly 34,000 km (21,000 mi) they encompass. Since this covers an average of two lanes, we only take 50% of the costs to yield $10.5 billion, which is close to the French's estimate of $9 billion. The charge to drivers is *0.29 cents/veh-km (0.47 cents/veh-mi)*.

## Water and soil pollution

Water pollution is significantly influenced by highway runoff. Substantial amounts of oil and grease from the roadway are washed into storm sewers during rainstorms. Road salt used during winter months creates a large amount of troublesome runoff. Besides impacts on flowing surface water, highway pollutants find their way into groundwater. This is considered by some environmentalists as a serious problem.

Presently the severity of groundwater impacts is not known due to lack of knowledge about salt and other contaminants in groundwater (Erickson 1982). Most of these contaminants are the result of the operation of highway vehicles, and increased traffic produces higher concentrations of these toxins around our nation's roadways.

## Vibration costs

Most studies look at the damage that vibration causes to vehicles, however, like noise, vibration causes damage to buildings located along the highway. Buildings and underground pipes often sustain damage due to the vibration caused by the operation of heavy-duty vehicles on nearby highways. Unfortunately, the repair costs for such damages fall upon the building owners, utility companies or municipalities without any compensation from the perpetrators. In addition, repeated vibration can also cause stress and fatigue. Assuming the cost of vibration to be half of the structural maintenance cost for buildings, Ketcham (1991) in his study, calculated the cost of vibration to be about $6.6 billion for 1989 ($7.5 billion -1992). He reckons that heavy vehicles are responsible for most of this damage.

### Litter

Every year, thousands of tons of litter are removed from this nation's highways. Dwindling landfill capacity, recycling mandates, and high costs for disposal in many areas, coupled with environmental restraints have complicated the task of disposal. The social impacts of litter are many including; eyesore in terms of aesthetics, detrimental to tourism, contributes to land and water pollution, degrades public lands, contaminates storm water runoff and contributes to hazardous materials on roadsides. The cost for this cleanup exceeds $120 million annually. None of these costs are charged directly to the users of the highway.

### The impact on unique resources

Architectural landmarks, historic properties, recreational parks and especially neighborhoods all suffer the consequences of unlimited highway travel and traffic. More importantly, increasing traffic volume disrupts neighborhoods. Community cohesion, living patterns and neighborhood activity all suffer at the hand of uncontrolled traffic. Urban highways often cut right through a neighborhood, dividing it into two separate entities (Erickson 1982). Highways also create negative visual effects for users and nonusers of the system. Besides litter, the propensity for numerous billboards along highways makes an unpleasant sight.

## ESTIMATED COSTS

It is extremely difficult to estimate the costs associated with water and soil pollution, litter, neighborhood disruptions, and unique resources. Nonetheless, these issues are raised here to make drivers aware of the many negative externalities that exist because of their numerous trips. We estimate that the individual costs of these social cost categories are very small. However, any revenue collected in "rounding off" driver fees for practical (collection) reasons, may be applied to cover these costs.

## CONGESTION COSTS

For those who experience congestion, the situation is extremely frustrating as traffic speeds dwindle and precious time is wasted in traffic jams. Drivers' travel times are adversely affected when there is an excess demand for road capacity. For example, if a motorist decides to enter a congested traffic stream, the addition of his/her vehicle influences the delay experienced by all other vehicles in the traffic stream. Every vehicle encounters further delay by any increase in traffic on that segment. The vehicle responsible for this delay is not held accountable, and therefore a social cost has been imposed on all other users. Since the driver pays the cost of his/her own delay, a marginal-cost user charge assures payment (accountability) for the additional delay caused to others.

The General Accounting Office cites estimates of national productivity losses from congestion at $100 billion annually, and estimates truck-delay costs from congestion of $24 to $40 billion per year (French 1991). The national cost of congestion for 1992 is estimated to be $107.5 billion nationwide.

### Travel delay costs

Travel delays due to congestion are extremely sensitive to location and time of day. This makes it difficult to calculate the marginal travel delay costs on a large scale. Therefore, to show delay costs, we select a 22.0 kilometer (14.0 mi) segment of urban highway (Eisenhower Expressway) located near downtown Chicago. With the aid of numerous detectors and sensors buried under the road surface, traffic patterns are monitored on a real-time basis making traffic data for this segment easily available.

Traffic volume counts showed the morning peak to be from 6am. to 10am. and the evening peak from 2pm to 7pm. Travel delays over these peak-periods are evaluated for speeds less than 88 kph (55 mph) by observing travel times longer than 0.7 mins/km (1.1 mins/mi). In analyzing close to 40,000 vehicles we found the maximum marginal delay to be 1.8 min/km (2.9 min/mi) with an averaged marginal delay over the nine-hour period of approximately 0.4 min/km (0.7 mins/mi). Assessing the value of time at $12.00/hr (Levinson 1994), the travel delay charges for automobiles on urban highways amounts to *8.0 cents/veh-km* (*14.0 cents/veh-mi*).

*Case Study:*

Urban Highway (Eisenhower Expressway- 22.0 km / 14.0 mi)

Free flow speed: 88 kph (55 mph)

Free flow travel time: 0.7 min/km (1.1 mins/mi)

Peak-period (am. & pm. peak): 9 hrs

Value of time: $12.00/hr

*Sample computation (at maximum volume):*

Initial no. of vehicles: $V_1 = 1291 \approx 1300$

Final no. of vehicles: $V_2 = 5915 \approx 6000$

Travel time at $V_1$: $T_1 = 0.7$ min/km (1.1 min/mi)

Travel time at $V_2$: $T_2 = 2.1$ min/km (3.4 min/mi)

$$\text{Marginal Delay} = \frac{(T_2-T_1)V_2}{V_2-V_1} \quad (1)$$

$$= \frac{(2.1-0.7)\ 6000}{(6000-1300)} = 1.8 \text{ min/veh-km } (2.9 \text{ min/veh-mi})$$

Peak-period Marginal Cost (averaged):

$MC_{av}$ = (0.4 min/km x $12.00/hr)/60

= *8 cents/veh-km (14 cents/veh-mi)*

## Wasted fuel

Vehicle-fuel consumption rates and emission rates depend on operating characteristics and are extremely sensitive to repeated acceleration and deceleration. The forced speed changes encountered while driving in congested situations decreases fuel efficiency considerably beyond increased tire and vehicle wear from braking. Travel delays caused by congestion lengthen trip times and directly influence fuel consumption. Newman and Kenworthy (1984) report that a 10% reduction in travel time produces a 3 to 7 percent savings in fuel consumption. Using the mid-range of 4%, the delay (averaged) of 0.4 min/km (0.7 min/mi) experienced by the vehicles in our study translates to a 24% increase in fuel consumption. Estimating the cost of fuel at $1.25 and fuel efficiency at 28 km/gal (18 mi/gal), the additional expense amounts to approximately *1.1 cents/veh-km (1.7 cents/veh-mi).* Since the costs due to the increased wear and tear on vehicles are costs already borne by the driver we do not charge for them.

*Computation:*

Free flow travel time = 0.7 min/km (1.1 min/mi)

Marginal Delay (averaged) = 0.4 min/veh-km (0.7 min/veh-mi)

Percentage Delay = 0.4 min/0.7 min ≈ 60%

Percentage increase (fuel consumption) = (60%/10%) x 4% = 24%

Fuel efficiency = 28 km/gal (18 mi/gal)

Fuel consumption = 0.036 gal/km (0.056 gal/mi)

Increase of 24% = 0.036 x 0.24 = 0.009 gal/km (0.013 gal/mi)

Cost @ $1.25/gal = 0.009 gal/km x $1.25 = *1.1 cents/veh-km (1.7 cents/veh-mi)*

## PARKING

Among travel costs currently subsidized, the expenditure attributed to parking is the highest. Since we cannot establish the percentage of highway trips that end at a parking facility, it is difficult to accurately charge for parking as part of an efficient toll. This cost if borne by the public or private sector is part of their overhead (cost to conduct business). Our concern is that free parking encourages the use of the automobile, thereby increasing congestion. Without doubt, free parking encourages solo driving, and far more Americans drive to work alone than would if they had to pay for parking. Someone other than the driver pays the staggering $85 billion annual tab for parking (MacKenzie 1994).

## SUMMARY AND CONCLUDING REMARKS

Increased travel increases the expense for every social cost category discussed so far. Enlightening highway users about the consequences of their actions will bring some control and reduction to unnecessary and unwarranted trips. If drivers are made to pay for the actual cost of travel, the use of urban highways will no longer be cost-free. The increased expense (toll) will induce better driving practices as drivers carefully weigh the benefits against the costs, before making any trip.

The social costs during non-peak travel sum to *2.3 cents/veh-km (3.7 cents/veh-mi)*. In comparison, travel during peak-periods is far more expensive with the addition of congestion costs. The value of time drives up these costs and the social costs amount to *8.7 cents/veh-km (13.9 cents/veh-mi)* for peak-period travel. If desired, one can add the operating costs (private costs) of an automobile to the social costs computed here, to get the total cost (actual cost) of driving on urban expressways. At *34.0 cents/veh-km (54.5 cents/veh-mi)* (Transportation Statistics Annual Report 1994), this cost totals to *36.3 cents/veh-km (58.2 cents/veh-mi)* for non-peak travel and *42.7 cents/veh-km (68.4 cents/veh-mi)* for peak travel. Though we do not calculate the fee to be exacted from trucks, including them in this paper demonstrates the impact they have on the social costs of driving.

Addressing social accounts as this paper does, will provide a basis for monitoring the evolution of social costs. It lays part of the framework for estimating social costs as they become better defined, measured and understood. This preliminary study serves as the first step towards educating drivers and providing a baseline against which progress can be measured.

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