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"Efficiency - Equity - Clarity"

Distance-Based Charges; A Practical Strategy for More Optimal Vehicle Pricing

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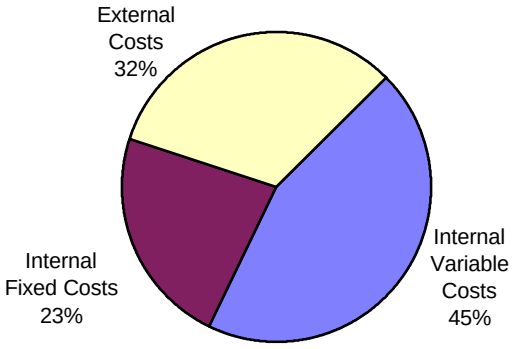
Abstract
Many costs of motor vehicle use are external, and a significant portion of the charges that vehicle users do pay are fixed, and therefore not marginal. This is economically inefficient and inequitable. Distance-based fees are the best way to charge for many costs imposed by vehicles, including road use, insurance, pollution emissions, and other environmental impacts. Distance-based charges are feasible and relatively inexpensive to implement with an "odometer audit," which means a verified recording of odometer data. This paper discusses the benefits of distance-based pricing, proposes a specific odometer auditing program, and describes the benefits that are likely to result from such pricing.

Key Words: Pricing, Economic Efficiency, Travel Demand Management (TDM), Vehicle Insurance, Odometers.

Optimal Pricing

Motor vehicle use imposes many costs, including several that are external and others that are internal but fixed, and are therefore not perceived as being related to distance driven.[1] Figure 1 illustrates the distribution of costs for a typical automobile, showing that less than half of all costs are marginal (internal and variable).

Figure 1 **Distribution of Automobile Costs**[2]



A majority of vehicle costs are fixed or external. "Internal Variable" includes vehicle-operating costs, user travel time and crash risk. "Internal Fixed" includes vehicle depreciation, insurance, registration, and residential parking. "External" includes congestion and accident risk imposed on others, a portion of road and parking facility costs, and various environmental costs.

This is economically inefficient, since the price users pay does not accurately reflect the costs they impose when making a particular trip decision. Only if drivers pay full marginal costs will they limit their vehicle travel to trips in which benefits exceed total costs. The current price structure is also inequitable, because it forces people who drive less than average to subsidize the vehicle costs of those who drive more than average. For example, a low-mileage vehicle owner pays far more per mile driven for insurance, registration fees, and local roadway funding (paid out of local taxes) than an otherwise comparable high-mileage vehicle owner. Since lower income households tend to own fewer vehicles and drive less than average, this is regressive.

To put this another way, our current pricing system fails to return to vehicle owners much of the savings created when they reduce their driving. For example, the average automobile owner perceives no financial savings for shifting from automobile to transit commuting, although actual savings average $1.00 to $5.00 per day when congestion, parking, accident and pollution costs are considered. A more marginal pricing system returns to individual consumers a greater share of these savings, increasing the incentive for more economically efficient travel. Shifting costs from being external or fixed to being internal and variable increases user choice. At worst consumers would simply shift the money saved to cover their higher variable expenses, resulting in no overall change in travel or cost. But they could enjoy savings that are not currently possible by foregoing low value trips or shifting to more efficient modes.

Transport professionals increasingly consider pricing strategies to help reduce infrastructure, congestion, and pollution costs.[3, 4] More optimal pricing requires that costs be internalized and marginalized (converted from fixed into variable charges) as much as possible, provided that transaction costs are not excessive.[5]

Table 1 **How Well Different Fees Represent Marginal Vehicle Costs**

Rank	General Category	Examples
Best	Time- and location-specific road and parking pricing	Variable road pricing, location-specific parking management, location-specific emission charges.
Second Best	Mileage-pricing	Weight-distance charges, mileage-based vehicle insurance, prorated MVET, mileage based emission charges.
Third Best	Fuel charges	Increase fuel tax, apply general sales tax to fuel, pay-at-the-pump insurance, carbon tax, increase Hazardous Sub. Tax.
Bad	Fixed vehicle charges	Current MVET, vehicle purchase and ownership fees.
Worst	External costs (not charged to motorists)	General taxes paying for roads and traffic services, parking subsidies, uncompensated external costs.

Table 1 ranks common vehicle charging options in terms of how well they represent the marginal costs of vehicle use. External costs, such as roads funded by general taxes, free parking, and uncompensated accident and environmental impacts are entirely non-marginal. Although fixed vehicle charges such as insurance and registration fees internalize costs to vehicle owners as a group, they are also not marginal, since once paid they have no effect on vehicle use. This is economically inefficient and results in cross-subsidies between those who drive less than average, and therefore impose relatively low costs, and those in the group who drive more than average and impose higher costs.

The most commonly used distance-based fee is a fuel tax. It is more marginal than an external or fixed fee, but is not optimal since it does not reflect many of the factors that affect vehicle costs, such as vehicle type, driver, and travel conditions. Fuel taxes implemented in a single state or province also have the problem that consumers often avoid the charge by purchasing fuel across borders.

A mileage or kilometer charge can be much more marginal. For example, it can be based on a particular vehicle's axle weight, accident risk, and pollution emissions. By prorating existing vehicle registration fees, distance-based fees can reflect both vehicle value and vehicle use, resulting in charges that are progressive with respect to income, since higher income people tend to own more valuable vehicles and drive more per year.

Road pricing that varies with time and place is even more marginal. It is particularly appropriate for internalizing congestion, accident and pollution costs. It is now technically feasible to use in-vehicle computerized meters or regional vehicle tracking systems to calculate vehicle charges, taking into account when and where driving occurs.[6] However, such a system is constrained by relatively high transaction costs and concerns about privacy. It is unlikely that electronic road pricing will be widely applied except as a demand management strategy in highly congested cities and for revenue generation on new highways for the foreseeable future.

The strategy which appears to have the greatest potential for more optimal pricing is use mileage or kilometer based fees to internalize external costs and convert currently fixed costs into variable costs. This can be accomplished at a moderate incremental cost and provides significant economic efficiency and equity benefits.

Implementing Mileage-Based Charges

Mileage charges are vehicle fees based on miles driven, using odometers as a meter. These charges require independent mileage readings, called an "odometer audit."[7] *Odometer audits* would be performed when a vehicle's license and insurance are renewed, in most cases once a year. Odometer auditing involves five steps:

1. Check speedometer for indications of tampering (signs that the speedometer unit or its cover has been removed, or marks on the counter face).
2. Attach a small seal to the ends of mechanical odometer cables to indicate if the cable has been disconnected. This is unnecessary on most newer vehicles which have electronic speedometers that are integrated with the engine computer.
3. Check tires for correct size.
4. If a dynamometer is available at the auditing station, speedometer and odometer accuracy can be checked (this step is optional).
5. Record odometer reading and forward results to the vehicle licensing and insurance agency. This data transfer could be done electronically.

Odometer audits performed alone typically take 5 to 10 minutes, plus vehicle owners' time and travel expenses. Costs are lower when auditing is performed in conjunction with scheduled vehicle servicing, such as an oil change or emissions check. Assuming most vehicles have audits performed with other vehicle servicing, and technicians chargeout rates average $60 per hour, total incremental costs should average about $10 per vehicle-year. Once the auditing system is established there would be little incremental transaction cost to make other fees mileage-based.

Auditing can prevent and detect most odometer tampering through physical evidence or discrepancies in odometer readings. Odometer fraud should be modest under mileage-based pricing, for the following reasons:

1. New vehicle odometers are increasingly tamper-resistant. Within a few years the majority of new vehicles sold are likely to have digital odometers that are difficult or impossible to reset. Some now have mileage data recorded in engine computers that can be checked to verify odometer readings. (Encouragement by federal or state governments or insurance companies could result in even faster penetration of tamper-proof odometers.) Since newer vehicles tend to get the most use, the vehicles with the greatest incentive for fraud will have the most tamper-resistant odometers.

2. Odometer tampering would typically save only $500-1,000, less than a quarter of what vehicle dealers typically gain when rolling back odometers to increase resale values.

3. Private vehicle owners do not have ready access to professional rollback experts. Amateurs often damage equipment or leave marks, exposing owners to repair costs and penalties.
4. Annual odometer audits would leave a record maintained in a database that could be reviewed for possible discrepancies by licensing and insurance agencies and future vehicle purchasers, making tampering easy to spot. In fact, this should greatly reduce odometer fraud by vehicle dealers. As a result, total odometer fraud should *decline* with mileage pricing.

Even if as many as 2-4% of vehicle owners altered their odometers to disguise half their true mileage, only 1-2% of mileage charges would be "stolen," a theft rate comparable to other consumer goods. Fraud rates are likely to be far lower than with current insurance pricing, which is based on self-reported estimates of annual mileage or commute distance, and on other factors that are seldom verified and entail minimal penalties.

Governments would establish an odometer audit certification program, similar to certification of vehicle emission check stations. Like other certification programs, odometer auditing could be self-supporting through fees. Auditors would typically be vehicle service stations, plus existing emission inspection stations. Insurance agencies might also be certified and offer free auditing as a marketing strategy. Most vehicle owners would probably get their odometer audit along with a scheduled oil change or other maintenance at minimal additional cost.

Mileage charges could be graduated in the interest of vertical equity. Rather than imposing, say, a flat 2¢ per mile charge, the rate structure could be 1¢ per mile for the first 4,000 miles, 2¢ per mile for 4,000-8,000 miles, and 3¢ per mile for travel over 8,000 miles. Such a fee structure recognizes that a certain amount of driving is a necessity, while higher mileage is discretionary for most households, and can be considered a luxury. Since lower-income households tend to drive less than average, this rate structure would be more progressive than a flat charge. While a graduated fee would provide a slight incentive for households to own more automobiles (since total mileage charges would be lower for two automobiles than for one for a given amount of travel) the overall effect should be slight, since savings (1¢ per mile for 4,000 miles = $40) are small compared with the costs of owning a second automobile.

High-mileage drivers might be tempted to register their vehicles outside a particular jurisdiction to avoid mileage charges. This concern applies primarily to weight-distance charges and emission charges, since mileage priced insurance and prorated motor vehicle excise tax would merely change the way existing charges are levied.

Table 2 shows the predicted impact of VMT charges.

Table 2 **Estimated Impacts of Mileage Fees In California**[8]

VMT Fee	Change in VMT
1¢	-2.3%
2¢	-4.5%
3¢	-6.6%
4¢	-8.7%
5¢	-10.7%

VMT Fee	Change in VMT
6¢	-12.6%
7¢	-14.5%
8¢	-16.3%
9¢	-18.0%
10¢	-19.7%

Some critics suggest that infrequent payments (such as once or twice a year) would have very low elasticities, but there is little evidence that this is true. As an indication that frequency of payment has relatively little impact on price sensitivity, there is no evidence that households that heat their homes with oil, and thus pay for heating once or twice a year, are any less interested in avoiding heat losses than households that heat with electricity or gas and pay for heat monthly or bi-monthly.

Applications of Mileage-Based Pricing[9]

1. Weight-Distance Charges

A weight-distance fee is based on the product of a vehicle's gross (or axle) weight multiplied by its distance driven. It is intended to cover the roadway costs imposed by each weight class of vehicle, taking into account the fact that bigger and heavier vehicles take more road space, cause more road wear and tear, generate more noise and cause more damage in crashes than smaller, lighter vehicles. Federal studies indicate that weight-distance fees would be the fairest and most efficient means of charging vehicle users for the roadway costs they impose.[10]

The relationship between roadway costs and user revenues has been widely studied in "cost allocation" or "cost responsibility" analyses.[11] These studies attempt to determine each vehicle class's share of roadway costs, particularly space requirements and road wear. All vehicles require a certain amount of space that can contribute to traffic congestion and the need to increase roadway capacity. Road wear increases by approximately the third power of vehicle axle weight, so that automobiles cause minimal wear while heavy vehicles can impose considerably greater costs.

Table 3 **Roadway Cost Responsibility Per Mile (From Tables II-6, IV-11, V-21)**[10]

Vehicle Class	Federal	State	Local	Total
Automobiles	$0.007	$0.020	$0.009	$0.035
Pickups and Vans	$0.007	$0.020	$0.009	$0.037
Single Unit Trucks	$0.038	$0.067	$0.041	$0.146
Combination Trucks	$0.071	$0.095	$0.035	$0.202
Buses	$0.030	$0.052	$0.036	$0.118
All Vehicles	*$0.011*	*$0.025*	*$0.011*	*$0.047*

To implement a weight-distance fee, a government would sponsor a roadway cost responsibility study to determine the appropriate fee for each vehicle class, traffic services (planning, policing, traffic lights, etc.) that can be considered mileage related. Table 3 shows average per-mile charges for various vehicle categories.

2. Prorating Registration and License Fees

Existing vehicle registration and license fees can be prorated by distance driven under this system to better represent road use costs. This means that an automobile that currently pays $360 per year for registration and licensing would pay 3¢ per mile, and one that pays $60 per year would pay 0.5¢ per mile. This allows the progressive nature of the current system (wealthier households tend to own more valuable vehicles, and so contribute more in registration fees) to be incorporated with a distance based charge.

Whether this should be added in addition or instead of other charges depends on the intent of current registration and licensing fees. If they are a road user charge, they should be incorporated into the charge described above. If they are a general property tax on vehicles, they should be charged in addition to road user charges. This would average about 1.5¢ per automobile mile, assuming $180 average annual payments and 12,000 annual miles driven.

3. Distance-Based Vehicle Insurance[12]

Distance based vehicle insurance means that current insurance rates are converted into per-mile (or per-kilometre) units, incorporating all existing rating factors, such as driving history, vehicle class, and territory. To implement it, state insurance law would be modified to require liability and collision insurance to be sold in distance-based units. This per-mile fee would incorporate all existing rating factors, such as driver's crash and moving violation history, vehicle type and geographic territory. For example, a low-risk driver who currently pays $300 per year for insurance would pay 2.5¢ per mile, while a driver in a high-risk class, who currently pays $1,200, would pay 10¢ per mile.

Pricing insurance by the mile is desirable from an actuarial perspective because within each risk class insurance compensation is well correlated to vehicle use. A change in any driver's annual mileage tends to cause an approximately proportional change in annual claim costs over the long term, whether it is a low-risk driver who averages an insurance claim every 100,000 miles, or a high-risk driver with one claim per 10,000 miles.

Mileage-based insurance allows individual motorists (rather than insurance companies or other drivers) to pocket the crash compensation savings that come from reducing driving. Because higher-risk drivers would have the highest per-mile insurance rates, and therefore the greatest incentive to reduce their driving, crash rates and total compensation costs should decline even faster than VMT.

Although insurers have always considered mileage an important risk factor, the additional costs of collecting accurate mileage data has prevented individual companies from instituting mileage pricing. This barrier would be overcome with statewide implementation.

Mileage-based insurance would also make vehicle insurance more affordable. Those who currently drive less than average in their rate class would save money because their low usage would be reflected in lower insurance payments. Those who currently drive more than average would also have an opportunity to save, by reducing vehicle use. The typical

vehicle owner is predicted to save $70 annually per vehicle, with greater savings to those who are particularly cost-conscious. Because mileage-based insurance aligns prices more closely to insurance compensation costs, it would increase economic efficiency and horizontal equity.

4. Emission Charges.
Emission charges represent air, water and noise pollution externalities. Ideally, they would be calculated using meters which measure emissions as they occur, taking into account location and time. However, this is currently considered too expensive to implement. A more feasible alternative is a per-mile emission charge based on average values for each vehicle class, or periodic testing of individual vehicles, augmented by roadside sensors to identify gross polluters.[13]

A distance-based pollution charge gives consumers an incentive to reduce emissions by driving less or using a lower emission vehicle, and is more equitable than a fixed pollution charge.[14] Lower income households tend to own relatively high polluting vehicles, but drive less than wealthier families, so a fixed annual emission charges is most regressive. Table 4 summarizes estimated air pollution emission costs. Other pollution emissions could also be incorporated into a mileage charge. Motor vehicles impose water and noise pollution costs, estimated to average 0.2-2¢ per vehicle mile.[2, 15]

Table 4 **Air Pollution Health Costs by Motor Vehicle Class ($1990 / VMT)**[16]

Vehicle Class	Low Estimate	High Estimate
Light Gasoline Vehicle	0.008	0.129
Light Gasoline Truck	0.012	0.188
Light Diesel Vehicle	0.016	0.225
Light Diesel Truck	0.006	0.116
Heavy Diesel Truck	0.054	1.233
Weighted Fleet Average	*0.011*	*0.213*

Total Impacts

Table 5 illustrates an example of these distance-based charges. On average, vehicle drivers would see their price per trip more than double, offset by a reduction in fixed charges and general taxes, although actual impacts would vary from one vehicle to another. Total vehicle travel would decline by approximately 25%, substantially reducing transportation-related externalities and inefficiencies.

Table 5 **Travel Impacts of Optimal Pricing**

Strategy	Average Fee	Travel Reduction
Weight-distance charges	$0.035	7.6%
Distance-based insurance	$0.060	12.6%
Distance-based registration fees	$0.015	3.3%
Emission fees	$0.030	6.6%
Totals	*$0.135*	*27.1%*

(Travel reduction estimates from Table 2. Total reduction calculated as:
1-([1- 0.076] x [1-0.126] x [1- 0.033] x [1-0.066])

About half of this price increase would result from converting currently fixed costs into variable costs. The rest would consist of charging motorists directly for currently external costs. Assuming that the revenue is returned to consumers through a reduction in other taxes or rebates, the overall economic and equity impacts could be quite beneficial.[17, 18] Reductions in vehicle travel resulting from optimal pricing represent an increase in social welfare. They consist of reductions in automobile travel that consumers value least and willingly forego, either by shifting modes or by avoiding the trip altogether. Trips that are made under current pricing that would be foregone under optimal pricing represent travel that provides less consumer benefit than its true cost.

Conclusions

Current motor vehicle pricing fails to convey to consumers the full costs of their decisions, or provide an appropriate financial reward to those who reduce their vehicle use. Many costs are external, and many internal costs are fixed. This is economically inefficient and inequitable. It leads to excessive automobile use that exacerbates a number of problems, including congestion, facility costs, accident damages, pollution and other environmental costs. A more optimal price structure, which internalizes currently external costs and marginalizes currently fixed costs could provide many benefits to society.

Although fuel taxes are the most common distance-based vehicle user fee, they do not effectively reflect most costs. Mileage-based pricing can much more accurately represent the roadway, accident and emission costs imposed by specific vehicles. Although road pricing that varies by time and location is even more optimal, particularly for congestion and pollution impacts, the application of such pricing is constrained by transaction costs and privacy concerns. Mileage based pricing appears to offer the greatest potential benefits for the foreseeable future.

Using the four mileage based prices recommended in this paper would result in a significant reduction in total vehicle travel. This reduction would consist of lower value trips that consumers are most willing to forego. This could benefit consumers and the economy, provided that revenues are used to reduce more economically burdensome taxes or returned as rebates.

Here are related reports available from VTPI:

Automobile Dependency and Economic Development

The Costs of Automobile Dependency

Distance-Based Vehicle Insurance

Potential TDM Strategies

Socially Optimal Transport Prices and Markets

Transportation Cost Analysis for Sustainability

Win-Win Transportation Management Strategies

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- Concepts that were not well explained.
- Analysis that is inappropriate or incorrect.
- Additional information, ideas or references that could be added to improve the report.

Thank you very much for your help.

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