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Distance-Based Vehicle Insurance As A TDM Strategy

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Abstract

Vehicle insurance is generally considered a fixed cost with respect to vehicle use. Motorists do not usually perceive insurance cost savings when they reduce mileage. *Distance-based* (also called *Pay-As-You-Drive* and *Per-Mile*) insurance pricing converts insurance to a variable cost, so premiums are directly related to annual mileage. Distance-based pricing makes vehicle insurance more actuarially accurate (premiums better reflect the claim costs of each vehicle) and gives motorists a new opportunity to save money when they reduce their mileage. It can help achieve several public policy objectives including equity, road safety, consumer savings and choice, congestion reduction, facility cost savings, energy savings and environmental protection. This paper compares several distance-based insurance pricing options, and evaluates concerns and criticisms. The analysis indicates that distance-based pricing is technically and economically feasible, and can provide significant benefits to motorists and society.

What would be the consequences if gasoline were sold like vehicle insurance?
With gasoline sold by the car-year, vehicle owners would make one annual advance payment which allows them to draw gasoline unrestricted at a company's fuel stations. Prices would be based on the average cost of supplying gasoline to similar motorists.

Unmetered fuel would cause a spiral of increased fuel consumption, mileage, and overall vehicle costs, including externalities such as accident risk, congestion and pollution. Motorists who use less fuel than average would find this unfair and unaffordable, and so would drop out of the system, but those who use more fuel than average would defend it because they enjoy benefits.

Such a system would be irrational. It is comparable to current insurance pricing.

An earlier version of this paper was published in *Transportation Quarterly*, Vol. 51, No. 3, Summer 1997, pp. 119-138. The comprehensive technical report of this study, *Distance-Based Vehicle Insurance; Feasibility, Costs and Benefits*, is available at www.vtpi.org/dbvi_com.pdf.

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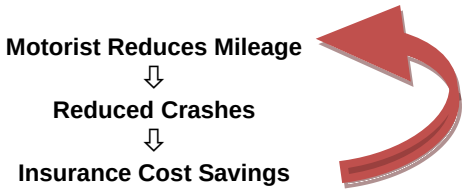
Introduction

This report explores the feasibility of implementing *distance-based* (also called *pay-as-you-drive*, *per-mile* and *usage-based*) motor vehicle insurance pricing. Insurance is currently a fixed cost with respect to vehicle travel. A reduction in vehicle mileage does not usually provide a comparable reduction in insurance premiums. Distance-based pricing converts insurance into a variable cost, so reducing a vehicle's annual mileage reduces its insurance premiums, all else being equal.

Distance-based insurance is based on the principle that prices should reflect costs, so consumers who reduce the costs they impose should receive proportionate savings. Reduced driving reduces the risk of crashes and insurance claims. With current pricing, claim cost savings that result when motorists reduce their mileage are retained as profits by insurers, or returned to premium payers as a group. With distance-based pricing these savings are returned to the individual motorist that reduces mileage. The less you drive the more you save, reflecting the insurance cost savings you create.



Distance-based pricing returns to individual motorists the insurance cost savings that result when they drive less. It rewards motorists for reducing mileage and makes premiums more accurately reflect the insurance costs of each individual vehicle.

Distance-based pricing gives motorists a new opportunity to save money. To illustrate this, consider the situation of a low-income worker who becomes unemployed and so reduces their vehicle travel. With current pricing they must continue paying the same insurance premiums, although both their income and crash risk decline. After extended unemployment they may find insurance expenses, and therefore vehicle ownership, a major financial burden. With distance-based pricing, motorists who reduce their mileage pay smaller premiums, but can still insure a car for essential trips, job searches, and temporary employment.

Distance-based pricing provides a marginal financial incentive to reduce mileage, allowing individual consumers decide which miles, if any to forego. Any vehicle-miles reduced consist of lower-value vehicle travel that motorists willingly give up in exchange for financial savings, representing a net consumer surplus. Motorists who continue their current mileage are no worse off on average with distance-based pricing (excepting any additional transaction costs), while those who reduce mileage are better off overall. To the degree that motorists reduce mileage, and therefore crashes and insurance claims, the savings that result are net benefits to society, not just economic transfers.

Distance-based insurance pricing can provide the following benefits:

- Increased actuarial accuracy, making premiums more accurately reflect the insurance costs of an individual vehicle, which is fairer and more economically efficient.
- Improved safety. It reduces total vehicle traffic, giving higher-risk motorists an extra large incentive to reduce mileage, and therefore the crash risk to themselves and other road users.
- Reduced average annual mileage by participating vehicles, which reduces traffic congestion, roadway costs, energy consumption, and pollution emissions.
- Consumer savings and affordability. Motorists have a new opportunity to save money, which is particularly beneficial to lower-income households.
- Reduced need for cross-subsidies from low-risk motorists to provide *affordable* coverage for higher-risk motorists. It should substantially reduce uninsured driving.
- Is progressive with respect to income. Since average annual mileage per vehicle increases with income, most lower-income motorists should save money.
- Improved consumer options. Motorists can choose the price structure that best meets their needs, and can afford to insure a vehicle that is driven low annual miles.

There are also barriers and costs associated with distance-based pricing:

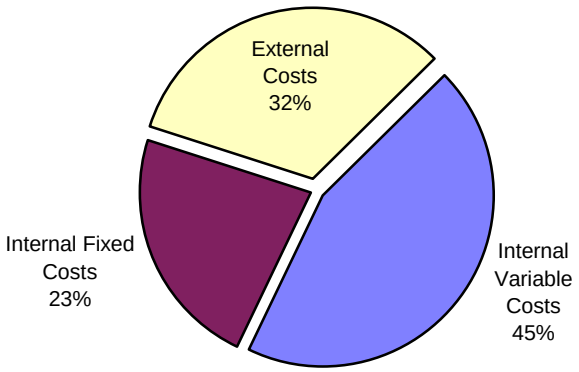
- It requires insurers and brokers to change how they calculate premiums, develop new procedures, and modify computer programs.
- When first implemented, insurers will face uncertainty as they develop actuarial experience with this rate structure.
- Distance-based pricing systems often increase transaction costs. Incremental costs range from less than $10 to more than $150 per vehicle-year, depending on the system used.
- It makes premiums and insurance revenues less predictable. Motorists and insurers would not know total premiums until the end of the insurance term.
- It increases premiums for some motorists.
- It has mixed political support, and there may be opposition from some stakeholders.
- Many people are skeptical of predicted benefits.

This report describes and compares various distance-based pricing systems, and examines their incremental benefits and costs. It discusses their implementation requirements and various concerns that have been raised about distance-based insurance.

Insurance Pricing

There is growing appreciation of the potential for market instruments to increase transportation efficiency and address specific problems such as congestion, pollution, and crashes (USEPA 1997). Current motor vehicle prices are economically inefficient, since prices do not reflect marginal costs ("Market Principles," VTPI 2004). Nearly a third of vehicle costs are external and a quarter are internal but fixed, as illustrated in Figure 1.

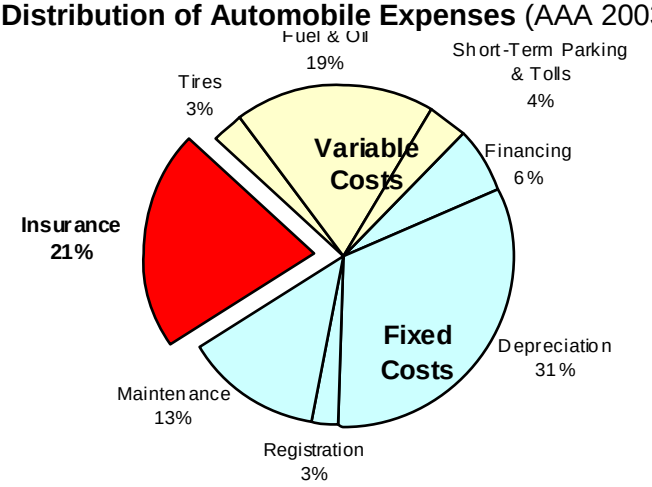
Figure 1 **Distribution of Vehicle Costs** (Litman 2004b)



A majority of automobile costs are either fixed or external.

Figure 2 shows the distribution of typical motor vehicle expenses. Most are considered fixed with respect to vehicle travel. Insurance is generally considered a fixed cost, since once a policy is purchased there is usually no savings from mileage reductions.

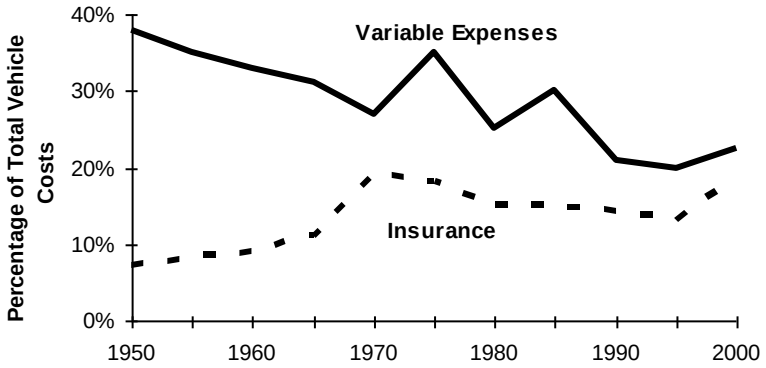
Figure 2 **Distribution of Automobile Expenses** (AAA 2003)



This figure illustrates the distribution of financial costs for an intermediate size car.

Although fixed vehicle expenses have increased during the last three decades, variable costs have decreased in real terms. As a result, variable costs as a portion of total costs have declined, as indicated in Figure 3.

Figure 3 **Vehicle Cost Trends** (MVMA 1995; AAA 2000)



The variable portion of vehicle costs declined from about 40% in 1950 to 22% in 2000.

Distance-based insurance increases variable vehicle costs without increasing total costs. Insurance premiums average about $850 per vehicle-year, resulting in distance-based premiums averaging about 7¢ per vehicle-mile.[1] Vehicle registration and licensing fees average about $250 annually, resulting in distance-based fees averaging about 2¢ per vehicle-mile. Fees of this magnitude would reduce vehicle travel by about 10-12%, as indicated in Table 1.

Table 1 **Mileage Fee VMT Impacts (USEPA 1998, based on Table B.21)**

VMT Fee	Change in VMT
1¢	-1.6
2¢	-3.1
3¢	-4.6
4¢	-6.0
5¢	-7.4

VMT Fee	Change in VMT
6¢	-8.7
7¢	-10.0
8¢	-11.2
9¢	-12.4
10¢	-13.6

This table shows predicted vehicle travel reductions from distance-based fees (updated to 2005 US Dollars).

[1] For average insurance premium data see the Insurance Information Institute (www.iii.org/media/facts/statsbyissue/auto).

Relationship Between Vehicle Travel and Crashes

Increased annual vehicle mileage tends to increase annual crash risk, all else being equal (CAS 1996, p. 35, 242 and 250; Litman 2004c; Ferreira and Minike 2010). Even a "perfect" driver faces risks from causes beyond their control—an animal running into the roadway, catastrophic mechanical failure, a heart attack—that increase with mileage. Annual crash risk is the product of two factors: per-mile crash risk multiplied by annual mileage. Although higher-risk drivers may crash every 50,000 miles, while lower-risk drivers may crash only every 500,000 miles, in either case a reduction in mileage reduces collisions.

Since about 70% of crashes involve multiple vehicles, each 1.0% mileage reduction should reduce total crash costs by 1.7%.[2] The elasticity of vehicle insurance costs with respect to mileage is between 1.42 and 1.85, which means that a 10% reduction in total vehicle mileage reduces total crash costs, insurance claims, and casualties by 14% to 18% (Edlin 2003).

High annual mileage drivers tend to have relatively low per-mile crash rates, as described in the box below. This reflects crash rates *between different motorists* and does not necessarily apply to mileage reductions by *individual motorists*. Most risk factors described in the box do not change when an individual driver reduces annual mileage. A motorist who drives 10% less in response to a price incentive does not usually become less skilled, take more chances or shift to a less safe vehicle as a result.

Higher-mileage vehicles tend to have relatively low per-mile crash rates because (Janke 1991):

- Higher-risk motorists tend to limit their annual mileage while high-mileage drivers are likely to be relatively capable drivers.
- Higher-mileage motorists tend to drive newer, mechanically safer vehicles.
- Urban drivers tend to have higher crash rates and lower annual vehicle mileage.
- Higher-mileage motorists tend to do a greater share of driving on grade-separated highways.

In the past, reliable information on the relationship between individual vehicles' annual mileage and crashes was unavailable. Most insurers collect only limited and self-reported mileage data, which vehicle owners often understate to qualify for lower rates. Other data are highly aggregate, based on total vehicle travel and crashes in a state. However, in the Vancouver, British Columbia region, mileage readings collected during emission checks were matched with individual vehicles' insurance claim records for more than 500,000 vehicle-years, providing reliable data.[3] Figure 4 illustrates the distribution of annual mileage categories (*mileage* refers to annual vehicle-kilometers in this context).

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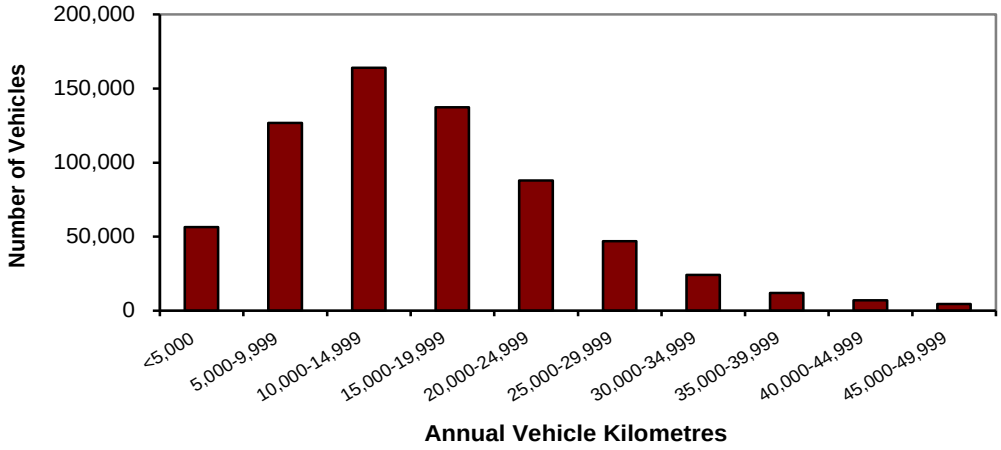
[2] For example, if you reduce your mileage by 10% you would expect a 10% reduction in your crash risk. If you did not reduce your mileage but all other motorists reduced their mileage by 10% you could expect a 7% reduction in crash risk, since 70% of your crashes involve other vehicles. If you and all other motorists reduce mileage by 10% you could expect a total 17% reduction in crash risk.

[3] For more information on this data set see, *Distance-Based Vehicle Insurance Feasibility, Costs and Benefits* (www.vtpi.org/dbvi_com.pdf).

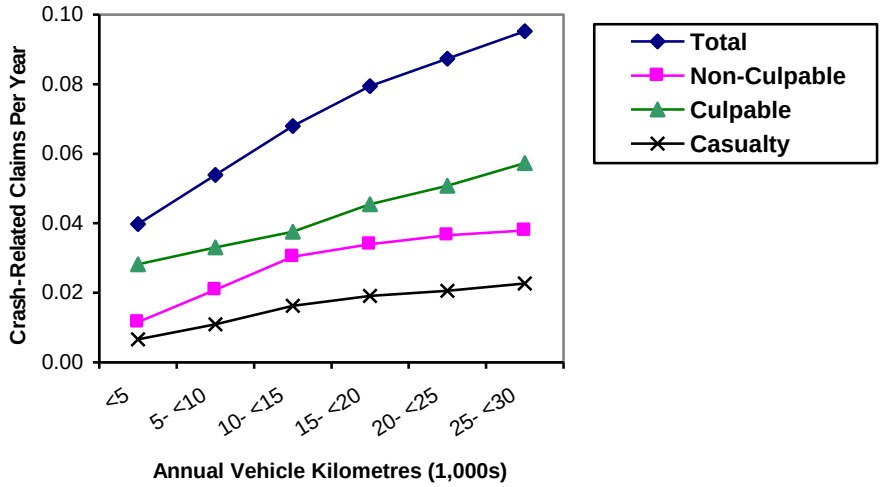
Figure 4 **Distribution of Annual Vehicle Mileage**



This figure shows the distribution of annual vehicle-kilometres in the database.

Figure 5 illustrates the crash rates by annual vehicle mileage for all records in aggregate.

Figure 5 **Crash Rates by Annual Vehicle Mileage**[4]



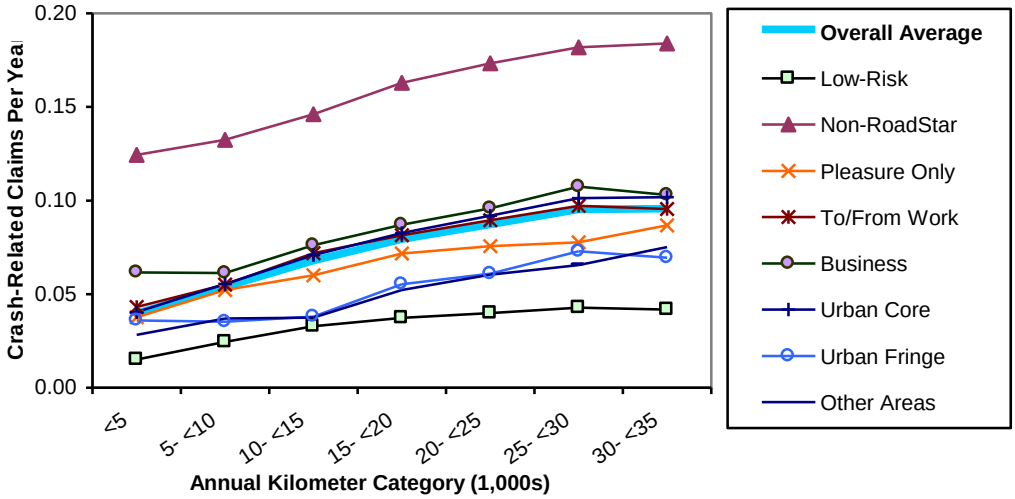
Annual crashes tend to increase with annual kilometres at the aggregate level.

Figure 6 shows crash rates by major category. Figure 7 illustrates crash rates for individual "Low-Risk" categories (vehicles with more than eight continuous years without a culpable claim). Annual crash rates tend to increase with annual mileage.

Because of the offsetting factors described above that result in relatively low per-mile crash rates for high annual mileage vehicles, and relatively high per-mile crash rates for low annual mileage vehicles, the relationship between annual mileage and annual crashes for individual vehicles is probably stronger than indicated by this aggregate data.

[4] British Columbia mileage and crash data.

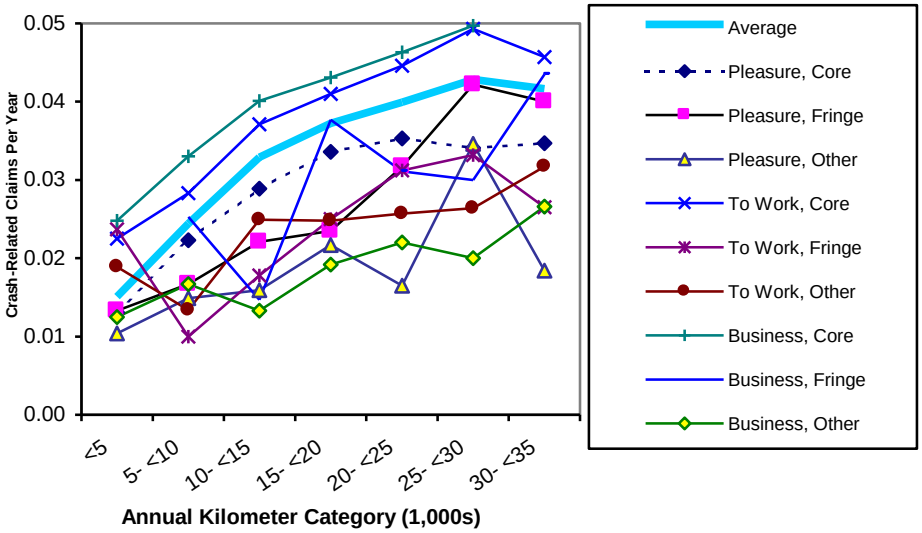
Figure 6 **Crashes Per Year By Major Category**



All categories show a positive relationship between crashes and vehicle travel.

These graphs and other analysis described in the comprehensive technical report show a strong positive relationship between annual vehicle travel and crashes in virtually all price categories. This indicates that distance-based pricing increases actuarial accuracy (i.e., makes premiums better reflect an individual vehicle's claim costs).

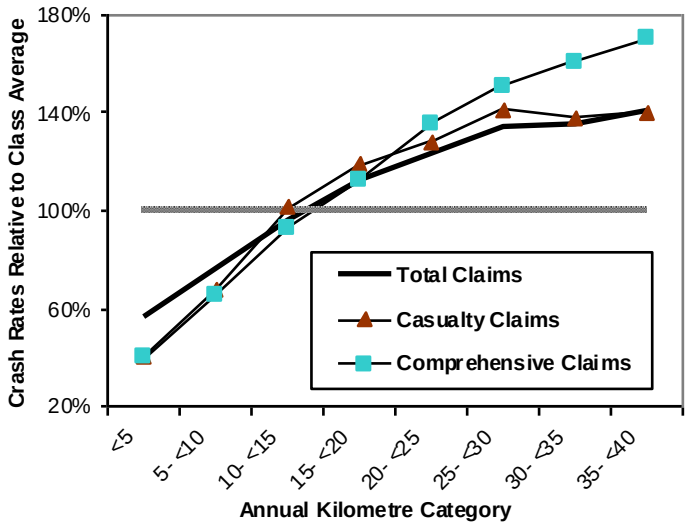
Figure 7 **Crashes Per Year By Category, Low-Risk Vehicles**



This figure shows that crash rates increase with annual mileage within price categories.

The data show that causality crashes (which involve an injury or death) and comprehensive claims (which involve vandalism, theft, weather damage and glass damage) also increase with annual vehicle mileage (Figure 8). This indicates that these types of vehicle insurance require distanced-based pricing to be actuarially accurate.

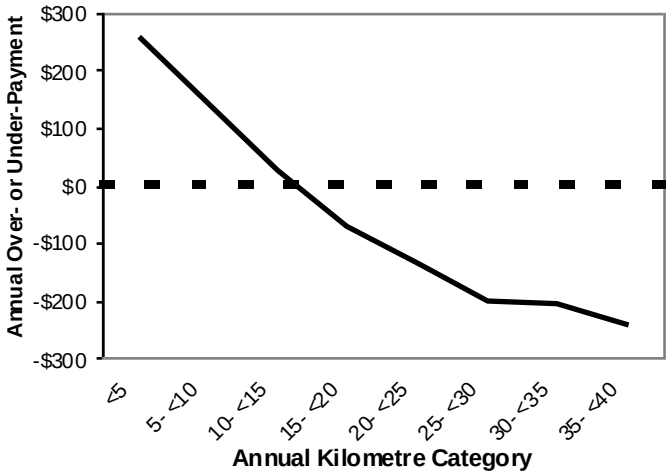
Figure 8 **Comprehensive and Casualty Claims**



This figure indicates that all types of crashes and claims tend to increase with annual vehicle mileage.

Because crashes and claims increase with mileage but premiums do not, motorists who drive less than average tend to overpay their true insurance costs, while motorists who drive more than average overpay within their rate category (i.e., motorists with the same risk ratings who pay the same size premiums for a given level of insurance coverage), as illustrated in figure 9.

Figure 9 **Over- and Underpayment Relative to Rate Category Average**



This figure illustrates the degree to which vehicles over- or under-pay their true insurance costs if pricing does not incorporate annual mileage.

Subsequent research provides further evidence of the positive relationship between mileage and crashes. Using Progressive Insurance Corporation data, Bordoff and Noel (2008), found a strong positive relationship between mileage and claims. Ferreira and Minike (2010) used mileage and insurance claim data matched for individual vehicles totaling 2.8 million vehicle-years. Their analysis found a significant correlation between miles driven and risk, and confirms that mileage is an accurate predictor of risk, particularly when normalized for other rating factors. Overall, these studies confirm the actuarial soundness of PAYD pricing.

Mileage - Crash Relationship Summary

The data show that crash rates increase with annual mileage in virtually all categories. Mileage is not the only risk factor. It is not necessarily the most important risk factor. But it clearly has a substantial impact. As a result, within existing rate categories lower mileage motorists overpay and higher mileage motorists underpay their insurance costs.

A critical question with regard to distance-based insurance is whether mileage reductions produce comparable reductions in crashes and claims. If not, insurers could face losses, since revenues decline more than costs. For example, if distance-based pricing causes a 10% reduction in mileage and premium revenue but only a 5% reduction in crashes and claims, insurers would be financially worse off. This could occur if lower-risk driving is more price sensitive than higher-risk driving. Some data described above suggest that this could occur, since marginal per-mile crash rates are nearly flat at very high-mileages, which implies that the last few thousand miles driven each year by a high-mileage vehicle has zero risk (in some cases it even suggests that increased mileage *reduces* crash risk). However, this reflects crash rates *between* different vehicles, not the result of mileage changes by *individual* vehicles.

All available data indicate that mileage reductions usually do reduce crashes and claims, and normally provide a proportionally *greater* reduction in *total* crash costs and claims by reducing both the risk of causing a crash and exposure to risks caused by another motorist. Available evidence indicates that a 10% reduction in mileage typically reduces total insurance claims by 14% to 18%, although a single insurer with a minor share of the vehicle insurance market does not capture all of these savings.

Distance-Based Insurance Pricing Options

This section describes four distance-based insurance pricing strategies.

1. Mileage Rate Factor (MRF) (Hundstad, Bernstein and Turem 1994)

Vehicle insurance could become more distance-based by incorporating motorists' estimates of their annual mileage as a rating factor into the existing price structure. This would be relatively easy to implement. However, motorists cannot predict with certainty how much they will drive in the future and tend to underestimate their annual mileage if they have a financial incentive. As a result, Mileage Rate Factor is inaccurate and can only apply a small portion of the actuarially justified weight on mileage.

2. Pay-at-the-Pump (PATP) *(Sugarman 1993; Wenzel 1994)*

Pay-at-the-Pump uses a 25-50¢ per gallon surcharge on gasoline sales to fund basic vehicle insurance. Table 2 summarizes the risks that are covered. PATP overcharges low-risk drivers with fuel-inefficient vehicles and undercharges high-risk drivers with fuel-efficient vehicles relative to their true insurance costs. To address this, most PATP proposals include additional surcharges on vehicle registrations, drivers licenses and traffic citations that reflect risk factors.

Table 2 **Pay-at-the-Pump Coverage**

Typically Covered	Typically Not Covered
• Basic liability for collisions by gasoline-powered vehicles that occur within the jurisdiction that has PATP.	• Extended liability. • Collision • Comprehensive • Out-of-jurisdiction travel. • Vehicles using fuel other than gasoline.

PATP only covers about a third of total insurance premiums; the rest continue to be fixed price. As a result, it only provides modest reductions in vehicle travel and modest overall benefits. PATP can cause significant revenue "leakage" from cross-borders and illegal fuel purchases (5-10% of vehicle mileage could be insured by PATP without paying the surcharge if a typical state or province implements PATP by itself). This creates a new inequity, since motorists who pay the surcharge would subsidize the insurance costs of motorists who avoid it.

PATP provides universal liability coverage for gasoline vehicles, which is attractive in jurisdictions with high uninsured driving rates. However, losses through cross-border and illegal fuel purchases would probably more than offset the increased cost recovery of uninsured driving. Other methods can effectively minimize uninsured driving, such as integrating vehicle insurance and licensing transactions (vehicle owners must pay for insurance to obtain license tabs), which has reduced uninsured driving to less than 1% in some jurisdictions.

3. Per-Mile Premiums (PMP) *(Butler 1993; Baker and Barrett 1998; Edlin 2003;* Bordoff and Noel 2008; Ferreira and Minike 2010*)*

This means that vehicle insurance is sold by the vehicle-mile (or kilometer) rather than the vehicle-year.[5] Other rating factors are incorporated into this price unit, so higher-risk drivers pay more per mile than lower-risk vehicles. For example, a $500 annual premium becomes 4¢ per mile, and a $1,000 annual premium becomes 8¢ per mile.

Motorists would prepay for the miles/minutes they expect to drive during the term, either in a lump sum or in several payments. For example, some motorists might pay for 12,500 miles at the start of the term, while others might pay for just 5,000 miles at first and make additional payments as needed. The total premium is calculated at the end of the term based on recorded mileage. Vehicle owners are credited for unused miles/minutes or pay any outstanding balance. There are three possible approaches to coverage:

A. Coverage only on prepaid miles/minutes. For example, if a vehicle owner pays for 5,000 miles, they have no coverage at 5,001 miles. This is the simplest approach and is appropriate for optional coverage, but would result in uninsured driving if applied to mandatory coverage.

B. Coverage regardless of prepayment. Once a driver makes a minimum payment they have coverage for the policy term (usually a year), and pay for any outstanding miles at the end of the term. For example, at the start of the term a motorist might pay for 5,000 miles of coverage but drive 15,000 miles. At the end of the term they would need to pay for the outstanding 10,000 miles driven in order to reinsure and reregister the vehicle. A problem with this approach is that motorists could avoid full payment by selling a vehicle outside the jurisdiction or scrapped it at the end of their term.

C. Coverage regardless of prepayment, with late payment penalties. This combines options A and B. Basic liability coverage would be provided for all travel during the policy term, but claims on unpaid miles or minutes would have financial penalties. For example, deductibles could double for claims that occur past the prepaid number of miles. This would give motorists an incentive to prepay, and would reduce insurance company's losses, since drivers who intend to avoid full payment would be stealing low value coverage.

Per-Mile Premiums requires *odometer auditing* to collect accurate vehicle-mileage data. Odometer audits would be performed when a vehicle's insurance is renewed, in most cases once a year. Audits involve these steps:

1. Check speedometer and instrument cluster for indications of tampering.
2. Record tire size and check that it is within the specified range.
3. Attach a small seal to the ends of mechanical odometer cables to indicate if it has been removed. This is unnecessary on most newer vehicles with electronic speedometers.
4. Check odometer accuracy and calibrate with a dynamometer (this is optional and could be performed on a random basis).
5. Record odometer reading and forward results to the vehicle licensing agency.

[5] A variation is to price by the vehicle-minute using an electronic instrument to measure engine operation. This concept is described in the comprehensive technical report.

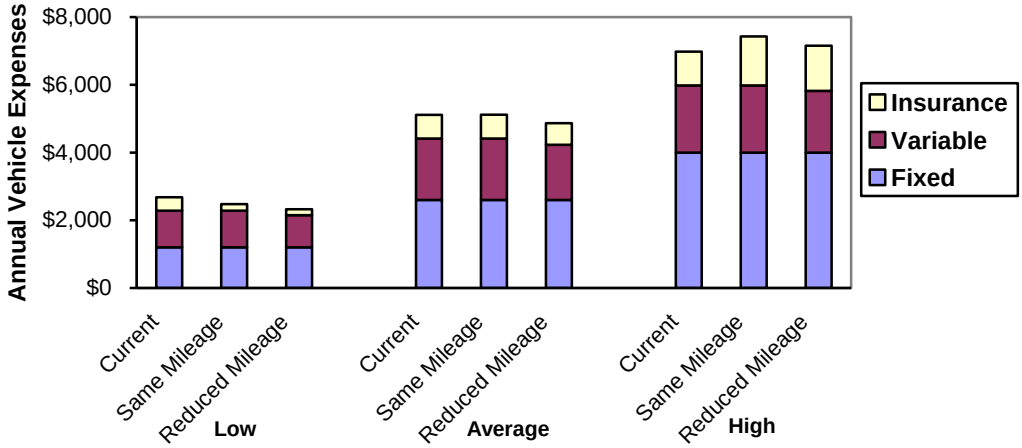
Audits take 5-10 minutes and less if performed with other vehicle servicing, estimated to average $5-10 per vehicle-year. Governments could certify auditors and incorporate odometer data into their vehicle registration database, or insurance companies could establish their own odometer auditor networks. Vehicle maintenance shops, emission inspection stations and some insurance brokers are likely to be certified.

There are concerns that odometer fraud could be a problem, but most tampering can be detected during audits and crash investigations, and fraud would void coverage. Odometers are increasingly tamper-resistant. Odometer audits should provide data as accurate as that used in other common commercial transactions and more accurate than self-reported information now used for insurance pricing. Audits would provide additional benefits, including accurate mileage data for used-vehicle buyers, and allows other charges, such as registration fees, to become distance-based at minimal extra cost.

Per-Mile Premiums could be implemented as a consumer option (NOW 1998; Oregon HB 3871). Motorists would choose between vehicle-year and vehicle-mile premiums, just as consumers can now choose their telephone service rates. Optional odometer-based PAYD would probably attract 20-40% of total policies, representing a significant portion of motorists who expect to drive less than 80% of average annual mileage in their rate class, representing 10-20% of total mileage. Participation should increase over time as fixed-rate premiums increase, eventually causing the market to shift to PAYD pricing.[6]

Figure 10 illustrates the financial impacts of Per-Mile Premiums on different types of motorists. A low-cost, low-mile vehicle owned by a low-income motorist might save $225, an 8.4% reduction in total vehicle expenses. An average motorist saves $64 annually in insurance costs if vehicle travel declines 10% as expected. A high-mileage motorist pays $331 more per year, a 4.7% increase in total vehicle expenses.

Figure 10 **Current and Per-Mile Premiums Annual Costs Compared**



This compares costs for Low, Average and High mileage vehicles. "Current" refers to vehicles with fixed-price insurance. "Same Mileage" refers to vehicles with Usage-Based Premiums that do not reduce annual mileage. "Reduced Mileage" assumes a 10% reduction.

[6] The first insurers to offer distance-based pricing are likely to attract many new customers.

4. **GPS-Based Pricing** (Bomberg, Baker and Goodin 2009)

This system prices insurance based on when and where driving occurs, using a GPS (Global Positioning System) transponder installed in each vehicle. It can incorporate virtually any rating factor related to driver, vehicle, time and location of vehicle travel. For example, an average motorist might pay 7¢ per minute for urban-peak driving, 5¢ for urban-off-peak driving, and 3¢ per minute for driving in rural areas. A lower-risk motorist pays less and a higher-risk motorist pays more.

This system typically adds $150 or more in annual costs for equipment, billing and royalties.[7] Privacy is a concern, although this can be address by controlling how vehicle location data are processed and stored.

In 1998 the Progressive insurance company introduced a pilot program of this system call *Autograph* coverage.[8] It has a $15 per month equipment fee, which allows participants to obtain other GPS services (panic button, roadside assistance, directional assistance, theft recovery, remote power door unlock, etc.) at a significant discount. Participants reduced their mileage more than 13% and saved more than 25% on average compared with conventional insurance pricing.

GPS-Based Pricing can attract motorists who drive low-mileage vehicles or want other GPS-based services, and who are not particularly concerned about loss of privacy (predicted to be 5-10% of current policies). This should increase somewhat over the next decade as more vehicles are manufactured with GPS transponders, but penetration would probably stay under 20% due to additional billing costs and privacy concerns.

Summary

The table below summarizes the pricing options evaluated in this report.

Table 3 **Summary of Distance-Based Pricing Options**

Name	Description
MRF	*Mileage Rate Factor* is incorporated into premiums.
PATP	*Pay-at-the-Pump* uses a fuel surcharge to provide basic insurance coverage for gasoline-powered vehicles.
Per-Mile, Mandatory	All vehicle insurance is priced by the mile or kilometer.
Per-Mile Ins. & Reg.	All vehicle insurance and registration fees are priced by the mile or km.
Per-Mile, Optional	Motorists may choose between vehicle-year or vehicle-mile premiums.
GPS-Based Pricing	Motorists may choose to purchase insurance based on when and where they drive using a GPS transponder installed in their vehicle.

This table summarizes the pricing options evaluated in the next section of this report.

[7] The Progressive Insurance Company's U.S. patent number 5,797,134 covers this technology.
[8] *Progressive Autograph*, Progressive Insurance, (www.progressive.com). This program is being studied by the USEPA (www.epa.gov/projectxl/progressive/index.htm).

Comparison of Distance-Based Insurance Options

This section compares distance-based pricing options by various criteria.[9]

1. Actuarial Accuracy

Mileage Rate Factor is constrained by the weight that can be placed on mileage before self-reported estimates of future travel are unacceptably understated. PATP is constrained because it uses fuel consumption as a surrogate for vehicle travel and then incorporates rating factors through fixed (not distance-related) surcharges on vehicle registration and drivers licenses, resulting in a trade-off between actuarial accuracy and distance-related pricing. Per-Mile Premiums can incorporate all existing rating factors, significantly improving actuarial accuracy. GPS-Based Pricing can incorporate existing rating factors plus travel time and location, and so is the most actuarially accurate pricing option.

2. Implementation Costs

Mileage Rate Factor using self-reported estimates of future travel has the lowest implementation costs. PATP has moderate to large transition costs, since it requires reorganizing the entire vehicle insurance system. It could reduce administrative costs for motorists who only purchase basic insurance, but most drivers would still need to purchase other coverages, so overall savings would be small.

Per-Mile Premiums require a new rate plan and an odometer auditing system. Most audits could be performed during other scheduled servicing, with an estimated incremental cost averaging $6 per vehicle-year. GPS-Based Pricing requires a GPS transponder installed in each vehicle, a tracking and billing system, plus royalties to use the technology. This is estimated to cost at least $150 per vehicle-year for most vehicles.

3. Travel Impacts

Table 4 indicates the magnitude of these per-mile costs, and the effects on vehicle travel, based on standard elasticity values. Figure 11 illustrates the travel reductions.

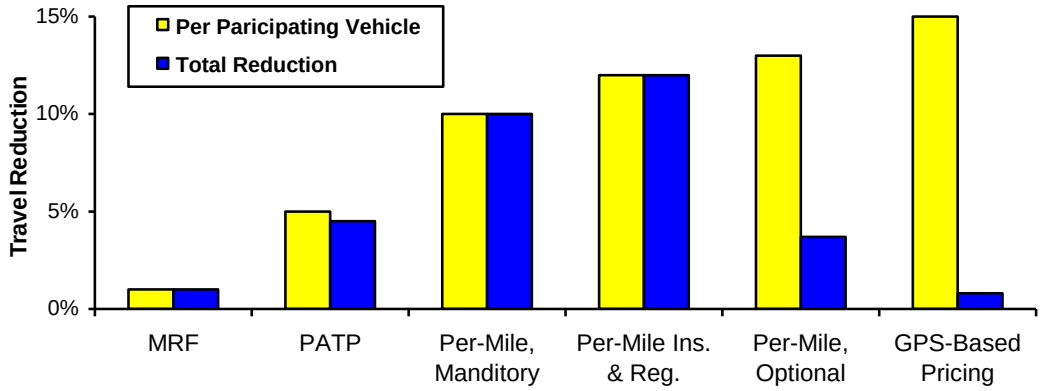
Table 4 **Travel Reduction Impacts**

	MRF	PATP	Per-Mile Mandatory	Per-Mile Ins. & Reg.	Per-Mile Optional	GPS-Based
Market penetration	100%	90%	100%	100%	50%	10%
Price increase per mile	0.7¢	1.4¢	5.6¢	6.8¢	5.6¢	5.6¢
Reduction per participating vehicle	1.0%	5.0%	10%	12%	13%	15%
Total vehicle travel reduction	1.0%	4.5%	10%	12%	3.7%	0.8%

This table compares the travel impacts of the various distance-based pricing options.

[9] Most impacts and benefits described in this section could increase about 10% if vehicle registration fees also become distance-based.

Figure 11 **Distance-Based Insurance Impacts On Vehicle Travel**



This figure compares travel impacts. Mileage reductions per participating vehicle depend on the size of the per-mile fee. Strategies with high implementation costs have low penetration rates and are only chosen by low mileage vehicles, so their total travel reductions are relatively small.

Distance-based insurance could increase vehicle ownership since it reduces fixed costs, but this is expected to be small (about 1%) and would add little additional vehicle travel. Most additional vehicles would be a household's second vehicle, such as an old truck or a collector car, which would substitute for, rather than add to, existing travel. Only drivers who purchase a first vehicle due to low fixed insurance costs are likely to drive more, and the annual mileage will be quite low; otherwise they would have no savings.

Some people suggest that Mileage Rate Factor and Per-Mile Premiums would have little effect on travel behavior because there would usually be several months lag between a reduction in mileage and consumers' financial savings, but this probably has a minor effect. For example, there is no evidence that households that heat with oil and so pay infrequently are less motivated to conserve heat (e.g., insulate, close doors and windows) than households that heat with electricity or gas and pay more frequently.

4. Road Safety

As described earlier in this report, each 1.0% reduction in vehicle mileage reduces total vehicle crash costs by 1.4% to 1.8%. PATP may provide somewhat smaller reductions in crash damages if it causes a shift to vehicles with less crash protection, although this impact is uncertain. Per-Mile Premiums give higher risk motorists an extra incentive to reduce their driving, and GPS-Based Pricing gives motorists an extra incentive to avoid higher-risk driving conditions, increasing their crash reductions (Bolderdijka, et al. 2010). The table below compares predicted crash reductions for the pricing options.

Table 5 **Estimate of Road Safety Benefits**

	MRF	PATP	Per-Mile Mandatory	Per-Mile Ins. & Reg.	Per-Mile Optional	GPS-Based
Total VMT reduction	1.0%	4.5%	10%	12%	3.7%	0.8%
% Crash reduction per % VMT red.	1.2	1.1	1.4	1.4	1.4	1.6
Total crash reduction	1.2%	5.0%	14.0%	16.8%	5.2%	1.2%

This table summarizes the safety benefits of distance-based insurance.

5. Energy and Emission

Mileage Rate Factor reduces energy consumption and emissions by about 1%. PATP reduces fuel consumption and CO_2 emissions by 13.5%. Per-Mile Premiums reduce energy consumption and emissions by 10%, and 12% if registration fees are also distance-based. GPS-Based Pricing provides an extra incentive to avoid congested conditions, therefore providing extra energy savings and emission reduction benefits per participating vehicle. However, its total impacts are small due to its limited penetration.

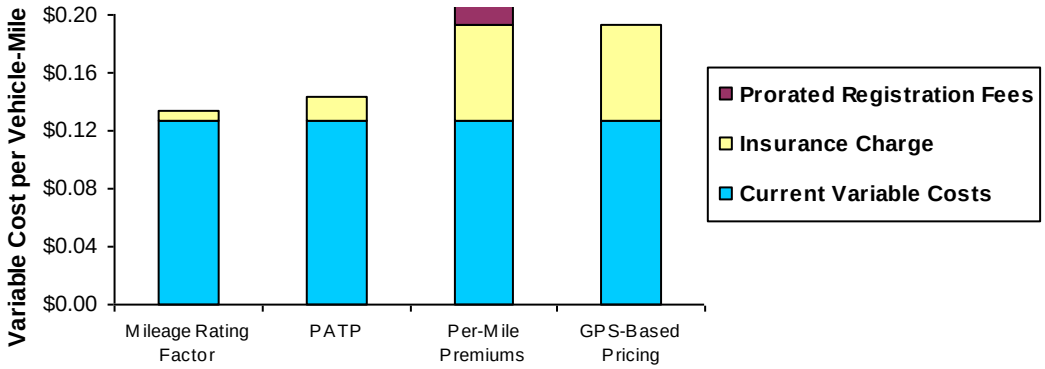
6. Congestion and Facility Cost Savings

Reductions in vehicle travel tend to reduce traffic congestion, and road and parking facility costs. Mileage Rate Factor causes small travel reductions and therefore provides little benefit. PATP causes modest travel reductions and therefore provides modest benefits. Mandatory Per-Mile Premiums provide the greatest travel reduction and therefore the greatest benefits, particularly if registration fees are also distance-based. GPS-Based Pricing provides an extra incentive to avoid congested conditions, but its total impacts are small due to its limited penetration.

7. Consumer Impact

Distance-based insurance gives motorists a new opportunity to save money. Average motorists who continue their current driving patterns pay the same as they do now (plus any implementation costs), while those who drive less save. Mileage reductions represent consumer benefits; low value vehicle travel that motorists forego in exchange for financial savings. The greater the travel reduction, the greater the consumer surplus gains. Figure 12 illustrates the increased variable costs from different distance-based insurance pricing options. Figure 13 illustrates impacts on total vehicle costs, which are modest because insurance is a minor portion of total vehicle costs.

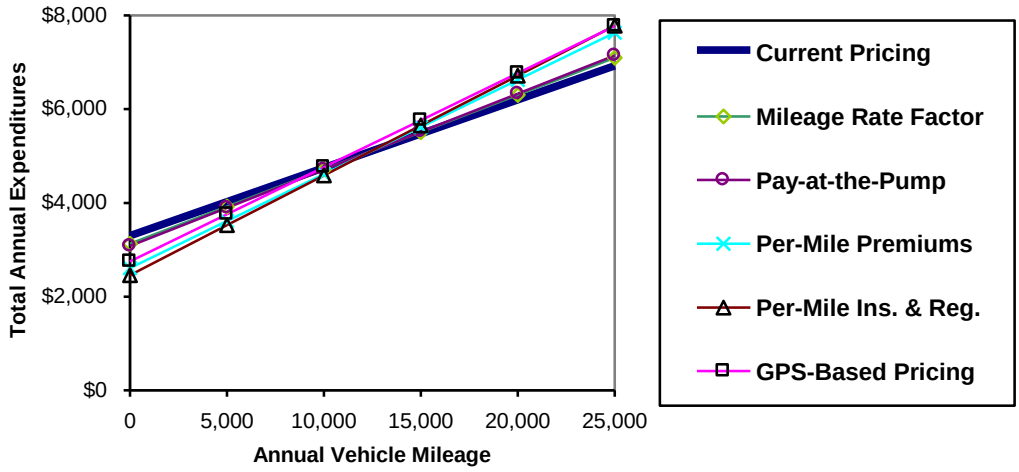
Figure 12 **Impacts On Variable Vehicle Costs**



This figure compares how each option increases per mile (variable) vehicle costs.

Only about 18% of vehicles are driven more than 15,000 miles annually, indicating that less than one in five drivers would pay significantly more (i.e., over 10%) with distance-based premiums. *Optional* distance-based pricing provides direct consumer benefits since motorists would only choose it if they considered themselves better off overall.

Figure 13 **Comparison of Total Costs By Annual Mileage**



This graph illustrates the effects different pricing options have on total vehicle costs.

8. Equity

Distance-based insurance helps achieve equity by more accurately reflecting crash costs (horizontal equity) and providing savings and increased choice to lower income households (vertical equity). Mileage Rate Factor slightly improves equity. PATP replaces current inequities with new inequities: overcharging lower-risk motorists with fuel inefficient vehicles who pay the premium, and undercharging higher-risk motorists with fuel efficient vehicles, and motorists who avoid paying the surcharge. Per-Mile Premiums provides the greatest overall changes in costs and so provides the greatest overall equity benefits. GPS-Based Pricing can be most actuarially accurate but its high implementation costs limit its availability, particularly to lower-income motorists.

9. Affordability

Distance-based insurance increases affordability by allowing consumers to purchase just as much accident risk as they can afford (Litman 2004a; Brobeck and Hunter 2012). Mileage Rate Factor provides minimal affordability benefits. PATP provides moderate affordability benefits. Per-Mile Premiums offer the greatest affordability benefits because they provide the greatest potential savings. GPS-Based Pricing has high implementation costs, and so cannot increase affordability for most motorists.

10. Economic Efficiency, Productivity and Development

Distance-based insurance increases economic efficiency by making prices better reflect marginal costs, and increases productivity by reducing externalities. Mileage Rate Factor provides minimal benefits. PATP is not actuarially accurate, provides modest externality reductions and can impose large economic costs on a jurisdiction by increasing cross-border and illegal fuel sales. Per-Mile Premiums provide the greatest economic benefits by more accurately reflecting costs and providing large externality reductions, particularly if registration fees are also distance-based. GPS-Based Pricing has minimal efficiency benefits due to high costs and modest market penetration.

11. Public Acceptability

There is likely to be strong support for *optional* distance-based insurance since it increases consumer choice and gives motorists a new opportunity to save money. Legislation supporting optional distance-based insurance (Oregon HB 3871) was endorsed by the National Association of Independent Insurers, regional governments, the American Automobile Association, the Oregon Consumer League, environmental organizations, citizen transportation reform groups and the Interfaith Global Warming Campaign (Hagerbaumer 2001).

Public response to *mandatory* distance-based insurance is mixed. Citizens generally support reforms that increase fairness and offer cost savings, and help solve specific problems, but are skeptical if it may raise costs or burden disadvantaged groups. Citizens may be uncomfortable with Mileage Rate Factor that relies on unverified mileage data. PATP appears to be the least popular option because it is perceived as a new fuel tax. Many objections to Per-Mile Premiums reflect misunderstanding of the concept and could be addressed by education and program design.

Consumers sometimes prefer the predictability and convenience of fixed prices, such as all-you-can-eat restaurants and flat-rate telephone service, but this preference is generally weak. Fixed-rate pricing is relatively uncommon in competitive markets, and some markets are shifting toward more variable pricing. For example, water utilities increasingly meter consumption, and electric rates are increasingly time-based. There is no evidence that consumers have a strong preference for fixed-priced insurance. Given the choice, most motorists who expect to save money would probably choose distance-based pricing.

Summary

Table 6 summarizes the rating of each price option according to the twelve criteria.

Table 6 **Impact Rating Summary**

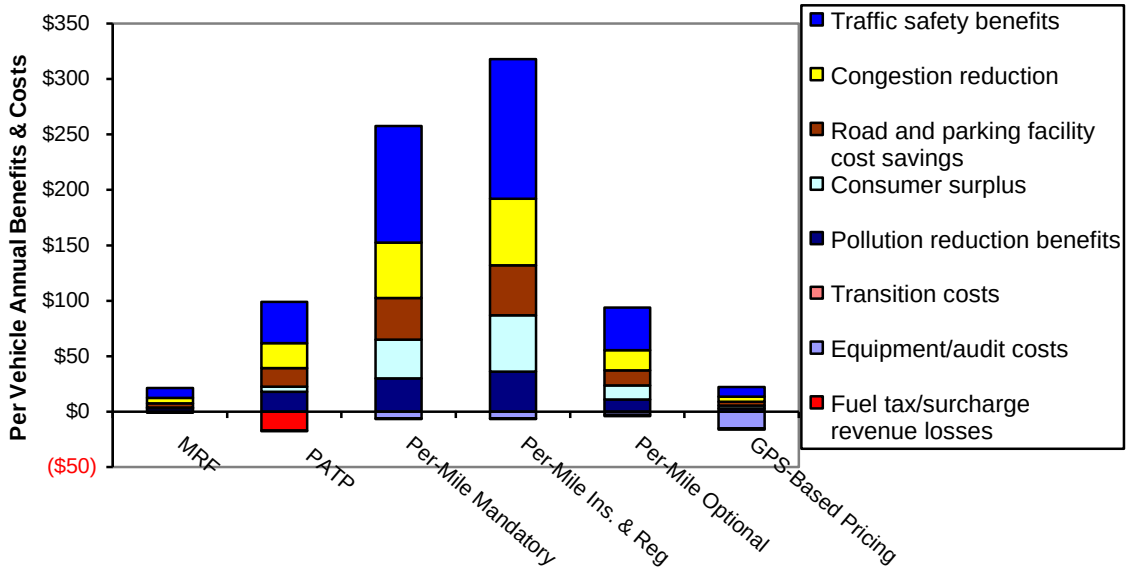
	MRF	PATP	Per-Mile Mandatory	Per-Mile Ins. & Reg.	Per-Mile Optional	GPS-Based
Actuarial Accuracy	1	0	2.5	2.5	2.5	3
Implementation Costs	-1	-3	-1.5	-1.5	-1	-3
Fairness	1	0	2.5	2.5	2.5	3
Progressive	1	-1	2.8	3	3	1
Consumer Impacts	1	2	3	3	3	1
Public Acceptability	1	0	2	2	3	1
Travel Impacts	1	2	2.8	3	2	1
Road Safety	1	2	2.8	3	2	1
Congestion Reduction	1	2	2.8	3	2	1
Energy/Emissions	1	3	2.8	3	2	1
Economic Development	1	-2	2.8	3	2	1
Totals	*9*	*5*	*25.3*	*26.5*	*23*	*11*

Rating from -3 (high cost/undesirable) to 3 (highly beneficial/desirable).

Mileage Rate Factor ranks high only in implementation cost. PATP ranks high in energy conservation/emission reductions, and medium in several categories due to its moderate travel reduction. Mandatory Per-Mile Premiums rank high in most categories because they cause a large cost shift and a large reduction in total vehicle travel, which increase further if registration fees are also distance-based. Optional Per-Mile Premiums rates lower in some categories due to its lower market penetration, resulting in smaller total vehicle travel reductions and associated benefits. GPS-Based Pricing can incorporate the most rating factors and so is most actuarially accurate, but its market penetration is limited, resulting in a relatively small reduction in total vehicle travel, and little increase in affordability. As a result its overall ranking is relatively low.

Figure 14 illustrates a benefit-cost analysis results. All six provide benefits that exceed incremental costs. Mileage Rate Factor has minimal implementation costs but vehicle travel impacts and overall benefits are small. PATP provides moderate benefits and high costs due to fuel tax revenue losses, and so has the lowest Benefit/Cost ratio. Mandatory Per-Mile Premiums have large total benefits, which increase if registration fees are also distance-based. Optional Per-Mile Premiums cause smaller total vehicle travel reductions and so benefits are modest. GPS-Based Pricing has minimal penetration and the highest per-vehicle implementation costs, and so has the smallest net benefits.

Figure 14 **Summary of Total Benefits and Costs**



This figure illustrates monetized benefits (above the line) and costs (below the line).

Both mandatory and optional Per-Mile Premiums have Benefit/Cost ratios that exceed 25. Even if costs were far greater than predicted (for example, if odometer auditing cost $20-40 annually per vehicle, rather than the $5-7 that is predicted), each of the five benefits would individually provide net benefits. This indicates that even under a worst-case scenario, with much greater costs and lower benefits than predicted, implementation of Per-Mile Premiums is still cost effective.

Consumer Impacts

Distance-based insurance pricing gives motorists a new opportunity to save money if they reduce their mileage. People sometimes misunderstand the source of these savings; they assume that the savings represent cost shifts, so each dollar of savings to motorists who reduce their mileage requires an additional dollar paid by higher mileage motorists. This is untrue. Much of the savings reflect true cost reductions provided by reductions in crashes and therefore insurance claim costs. With current insurance pricing, motorists who reduce their mileage provide savings that benefit their insurance company or all motorists in their rate class, with distance-based insurance individual motorists receive the savings that result when they reduce their mileage.

Since DBVI offers a new opportunity for savings, the mileage reductions provide consumer benefits. For example, if a motorist who shifts to distance-based insurance with 10¢ per vehicle-mile premiums responds by reducing their vehicle travel 10%, or 1,200 annual vehicle-miles, as models predict, we can surmise that these miles foregone have an incremental value to that motorist ranging between 0¢ and 10¢. If those miles were worth less than 0¢ (they provide no incremental consumer benefit), they would not be driven in any case. If they consider those miles worth 1-9¢, the additional 10¢ per mile savings will convince them to give it up, they would rather have the money. If the additional mile is worth more than 10¢ per mile, a 10¢ per mile savings is inadequate to convince motorists to forego that mile, they will continue driving. Of the 1,200 miles foregone, we can assume the average consumer surplus (net consumer benefit) is the mid-point of this range, that is, 5¢ per vehicle-mile. Thus, we can calculate that miles foregone by a 10¢ per vehicle-mile premium have an average consumer surplus value of 5¢, or a $60 overall increase in consumer surplus (1,200 miles times $0.05 per mile).

Under most scenarios, distance-based insurance would be a consumer option, so individual motorists could choose the pricing structure that best meets their individual needs just as consumers can choose various price structures for telephone and internet services (per minute, a bundle of minutes, or unlimited usage). This reflects the principle of consumer sovereignty, the idea that consumers benefit from having diverse goods (including different types, qualities, and price options) from which they can choose the combination that best meets their needs.

To the degree that lower-mileage motorists overpay their true insurance costs and cross-subsidize higher mileage motorists, distance-based pricing may eventually increase premiums for conventional (flat-rate) policies, as more lower-annual-mile motorists shift to distance-based policies. Such increases should be gradual and predictable, with a few percent of motorists shifting to the new price structure each year, forcing insurers to raise flat-rate premiums a few percent a year. This will raise the annual mileage point at which motorists consider distance-based insurance attractive. These price increases reflect the actual costs of insuring higher-annual-mileage vehicles and so reflect increases in economic efficiency and equity. Bordoff and Noel (2008) estimate that in the U.S., lower-annual-mileage motorists overpay an average of $318 annually compared with what is actuarially accurate, and PAYD would provide direct net savings to about two-thirds of all motorists.

Responses to Concerns About Per-Mile Insurance

This section discusses concerns that have been raised about distance-based pricing.

Insurance pricing already incorporates mileage.
Some insurance companies incorporate mileage-related rate factors such as commute distance or estimated annual mileage, but none begins to approach actuarially accurate, marginal pricing, so they fail to give motorists accurate price signals.

Mileage is less important in predicting crashes than other rating factors.
Insurance industry claims that annual mileage is not a significant risk factor based on inaccurate, self-reported data. New research based on independently-collected mileage data shows a strong relationship between mileage and crashes. Whether mileage is more or less important than other risk factors is irrelevant for DBVI pricing that incorporates other rating factors. Although it would not be actuarially accurate to use mileage instead of other rating factors (for example, to charge all motorists the same 6¢ per mile for insurance), actuarial accuracy increases significantly if mileage is added to other rating factors, so for example, a lower-risk motorist pays 3¢ per mile and a higher risk motorist pays 12¢ per mile).

Travel foregone could be lower risk than average, resulting in little crash reduction, and less insurance cost savings than reduced premium revenue.
This concern is technically valid, although there is no evidence that it is true. Available evidence indicates that DBVI reduces both high and low risk travel, and broad vehicle travel reductions result in proportionally greater crash reductions and insurance savings. Additional research and pilot projects that test the effects of distance-based pricing could address this concern.

DBVI pricing increases costs to low-income motorists.
DBVI provides significant savings and benefits to most lower-income motorists, including those who currently drive less than average, those who drive somewhat more than average but will reduce their mileage in response to this price incentive and so save money, those who currently drive uninsured because they cannot afford insurance, and those who currently cannot afford to own an automobile due to high insurance costs until DBVI becomes available. Butler (2000) describes how fixed insurance pricing creates a spiral of rising premiums and uninsured driving rates that harm low-income communities.

DBVI pricing unfairly increases costs to high-mileage drivers.
DBVI increases premiums for motorists who drive significantly more than average within their rate class. This is justified on actuarial grounds, and so increases fairness. Most motorists save money and benefit overall, particularly lower-income motorists, who tend to drive less than average within their rate groups.

DBVI pricing unfairly increases costs to rural residents.
Since territory is a rate factor, only rural motorists who drive significantly more than the average among rural residents would pay more. For example, motorists average 12,000 annual miles but rural motorists average 15,000, so rural residents who drive 14,000 annual miles would save money—although this is more than the state average—because it is less than the rural average.

Automobile insurance reform should focus on equity, affordability and safety.
DBVI pricing helps achieve all of these goals. It increases equity by making premiums more actuarially accurate. It makes vehicle ownership more affordable and provides financial savings, particularly for lower income motorists. It also significantly increases road safety.

There are other ways to achieve safety, mobility, energy conservation and environmental goals.
It is unnecessary to choose between DBVI pricing and other strategies. Distance-based pricing complements other strategies. Because of its multiple benefits, DBVI insurance can be one of the most cost-effective ways to achieve these objectives.

People need their cars too much to give them up. There will be no travel reduction.
DBVI is not expected to cause people to give up cars. There is extensive evidence vehicle operating costs affect vehicle travel activity. A 5-15% mileage reduction is projected based on standard motorist price responses.

Consumers will not accept this change.
Market surveys and pilot projects indicate significant consumer demand for distance-based pricing. A broad range of interest groups support DBVI pricing. Support should increase as consumers and citizens learn more about this concept.

Odometer fraud will be a major problem.
Although some fraud may occur, it should be minor overall, with fraud rates comparable to other common consumer transactions, and far lower than with current insurance pricing based on self-reported predictions of future mileage. Odometers are increasingly tamper resistant, regular odometer audits should discourage tampering, and the financial incentive for fraud is relatively low. Insurers' financial exposure would be minimal since odometer fraud voids coverage.

It increases administrative costs to insurers and inconvenience vehicle owners.
Although any price change adds short-term transition costs, these are minor, and tiny compared with total benefits. Odometer audits should cost $5-$15, and less if performed in conjunction with scheduled maintenance such as an oil change or emission inspection.

This type of pricing has never been used before.
Some vehicle insurance is already distance-based: rates for fleets and commercial vehicle coverage are often based on mileage. Several insurers now offer DBVI policies. There is nothing unique about pricing based on use. Prices for most goods are based on some measure of consumption, such as water and electric meters, and scales used to weigh food. Vehicle rentals and leases incorporate odometer-based price components. Vehicle insurance is unusual for having pricing that allows unlimited consumption (i.e., vehicle mileage).

DBVI pricing would be an invasion of privacy.
Odometer auditing does not identify when or where a vehicle has been driven, or provide any other information that could be considered private. Odometer readings are already collected during vehicle servicing, vehicle sales and crash investigations. Odometer readings are even sold by private companies to used vehicle purchasers. Odometer auditing simply standardizes the collection of this information. Odometer auditing would provide additional benefits. For example, it would prevent odometer fraud by used vehicle sellers (since a reliable record of past odometer readings would be easily available) and provide data useful for transport planning.

Some DBVI systems do track when and where a vehicle is driven, and so may raise legitimate privacy concerns. However, this would be a consumer option, and these systems can be designed with controls over how the vehicle location data are processed and stored, as with other personal data such as telephone calls and credit card transactions. Many motorists already choose to collect this information for security and auditing purposes.

Table 2 **Obstacles and Potential Solutions**

Obstacle	Potential Solutions
Misunderstandings. Many objections to DBVI pricing reflect misunderstandings of the concept. Some people believe it refers to Pay-At-The-Pump (insurance coverage funded through a fuel sales surcharge), are unaware of its full potential benefits, or have exaggerated estimates of its costs.	Educate stakeholders (policy makers, insurance professionals, insurance regulators, consumers) about DBVI, including how it would be implemented, and its real benefits and costs.
Uncertainty. Current rate structures are based on claim cost data collected by the vehicle-year. Although there is ample evidence that mileage is an important risk factor, actuaries have insufficient data to know exactly how to calculate mileage-based premiums.	Begin with a relatively small pilot project, using a basic prorated premium (i.e., current annual premiums divided by average annual mileage for each rate class), with an extra 5-15% margin to account for uncertainty. Adjust this rate as needed as the pilot project provides data.
Data accuracy. DBVI requires accurate mileage data. Self-reported data is unreliable.	Mileage data can be collected in many ways. The cheapest is for motorists to report odometer readings, verified with occasional spot-checks. The most costly is to install GPS transponders in each participating vehicle. An intermediate approach, which may provide the optimal balance between accuracy and cost, is to certify businesses (emission stations, service stations, and brokers) to perform odometer audits.
Exaggerated number of losers. Some people object to DBVI because they believe it would harm many groups, such as rural drivers (DBVI, as recommended here, would only increase costs for rural motorists who drive more than the average for rural motorists) or businesses (premiums for business vehicles already reflect their relatively high mileage).	Educate stakeholders about DBVI insurance real distributional impacts. To the degree that it is effective at reducing mileage and crash costs, most people should benefit overall. Even high mileage drivers can benefit overall if they prefer owning multiple vehicles, and due to reduced exposure to traffic congestion, accident risk and pollution emissions.
Regulatory constraints. Some insurance regulations discourage pricing reforms. For example, regulators often require insurers to provide data justifying rates, and some prohibit insurers from offering multiple rate structures. Regulations are complex and rate filings are costly (often costing a million dollars or more in data collection, analysis and paper works), which discourages small, innovative pilot projects.	Educate insurance regulators concerning the merits of DBVI with respect to insurance regulatory objectives. Collect data showing the actuarial basis for DBVI. Work with regulatory agencies to address specific obstacles to innovation and small pilot projects. Identify jurisdictions that have suitably supportive regulatory policies. Pass legislation (as in Oregon and Texas) which specifically allows DBVI insurance pricing.
Lack of incentive. Insurance companies currently perceive little incentive to implement innovative pricing options such as DBVI pricing.	Educate insurance company officials concerning opportunities to profit from DBVI pricing (the first companies to offer this product should attract significant new business). Provide financial incentives, such as tax breaks (as Oregon now does). Pass laws requiring insurance companies to offer DBVI, at least as an option. Fund DBVI research programs and pilot projects. Favor insurance companies that offer DBVI pricing in government contracts.

This table lists various obstacles to DBVI pricing, and potential solutions to them.

Examples and Case Studies

MileMeter (www.milemeter.com)
MileMeter is a private insurance company which began selling PAYD insurance policies in Texas in 2008. All policies are valid for the amount of miles purchased or a six (6) month period. Policies are purchased by the Internet. Motorists report their odometer reading when they purchase a policy. This information is cross-referenced with odometer readings from vehicle emission, maintenance, and registration databases nationwide to insurance accuracy.

Coverbox (www.coverbox.co.uk/index.php)
Coverbox is an Internet-based brokerage firm that uses mileage recording device installed in vehicles to calculate insurance and theft tracking. Policy mileage rates vary depending on when a vehicle is driven, with off-peak, peak and super-peak. Motorists pay premiums based on their projected future driving patterns. At the end of the policy term the rates are adjusted to reflect actual driving during that period; motorists receive a rebate if their actual mileage is less than projected or pay for any additional mileage charge needed. Several insurance companies including Co-operative, Allianz and Equity Red Star offer Coverbox PAYD policies.

Real Insurance PAYD (www.payasyoudrive.com.au)
Starting in 2008, Real Insurance began offering *Pay-As-You-Drive* vehicle insurance in Australia. Motorists report their odometer reading at the beginning of the policy term and purchase a certain number of kilometers. Odometer readings are verified if there is a claim, giving motorists an incentive to be accurate (false readings void coverage). Any unused kilometers are either refunded if motorists cancel or don't renew (upon verification of vehicle odometers if requested by the company) or carried over to the next policy. If kilometers exceed prepayment the policy only provides basic coverage (liability, fire and theft). Policy holders can easily purchase additional kilometers at any time. This program was awarded Australia's Cheapest Car Insurance award by *Money Magazine*. A Magazine spokesperson said, "In these tough times consumers need to reduce costs wherever they can and shopping around for car insurance is a must. *Money Magazine* is pleased to be able to recognise and reward the best products and services – particularly at a time where it's so critical for consumers to rein in their spending."

PAYD in State Emission Reduction Plans
Of 33 state climate action plans evaluated by the New America Foundation Climate Policy Program, twelve include PAYD as a transportation emission reduction strategy, as summarized in www.newamerica.net/files/State%20Climate%20Policy%20Tracker%205-4-09.xls. These states include: AZ, CA, CO, MD, ME, MN, NH, NM, NC, RI, VA, and VT. The degree of emphasis and support for PAYD varies. For example, the Rhode Island plan, while endorsing the importance of the strategy, explicitly says that the state will likely wait for other states to figure out how to promote PAYD insurance before it does so. Justin Horner of the National Resources Defense Council described this analysis in the following blog:
http://switchboard.nrdc.org/blogs/jhorner/thirteen_states_say_ok_lets_ha.html

PAY PER K Coverage (www.nedbank.co.za).
Nedbank, a major South African insurer, now offers *Pay Per K* vehicle insurance, which bases premiums on monthly mileage. *Pay per K* monitors the distance a vehicle is driven each month by means of a NedFleet card that is linked to the vehicle's comprehensive motor insurance. Each time the vehicle is refueled an odometer reading is recorded and used to calculate a monthly insurance bill. Monthly premiums will fluctuate depending on the distance traveled in the preceding month, and are debited monthly in arrears. This means motorists only pay for those times when their vehicle is actively on the road and therefore most at risk.

Polis Direct Kilometre Policy (www.kilometerpolis.nl)
Polis Direct (www.polisdirect.nl), a major Dutch insurance company, began offering their "Kilometre Policy" in November 2004. Participating motorists must be at least 24 years of age, have a car that sold new for less than €42,000 (euros), and drive less than 40,000 kms annually. Per-kilometer premiums are calculated by dividing current premiums by the current policy's maximum annual kilometers, which is typically 20,000, so a motorist who currently pays €500 for up to 20,000 kilometers would pay €0.025. Participants pay an "advance premium," which is 90% of their current premiums, so those who currently pay €500s under this system pay an advance premium of €450. At the end of the policy term the motorist receives a rebate of up to 50% of their premium for lower mileage (in this case, a rebate up to €250 if they drive less than 10,000 kms), or their premiums can increase up to 50% if they drive more than the current maximum (in this case, they could pay up to €750 if they drive 30,000 kilometers during the policy year. If this motorist drives 20,000 kilometers they pay an extra €50, so their total premium is the same as with a standard policy. In the following years the advance premium is calculated based on the number of kilometers actually driven the previous year. Mileage is calculated using odometer readings collected during annual vehicle inspections, called the "national car card," and recorded in the national vehicle registration database.

Holland PAYD Coverage (www.payasyoudrive.co.za).
Holland Insurance (www.hollard.co.za), South Africa's largest insurer, offers *Pay-As-You-Drive* vehicle insurance. Monthly premiums are based on the distance traveled in the preceding month. Mileage is automatically recorded a Skytrax GPS tracking device. An article by the *Mail & Guardian*'s Personal Finance columnist Maya Fisher-French explains, based on her own experience, how this system allows motorists to save money by reducing their mileage (www.payasyoudrive.co.za).

Progressive MyRate (www.progressive.com/MyRate/myrate-default.aspx)
The Progressive insurance company offers *MyRate* policies which provide discounts based on based on when, how much and how a vehicle is driven. Cars that are driven less often, in less risky ways and at less risky times of day can receive large discounts. Participating motorists receive a MyRate device which they plug into their vehicle's On-Board Diagnostic (OBDII) port, which records how much, how fast and when the vehicle is driven. This information is used to calculate discounts the customer may receive when they renew their policy. The device reports driving information by wireless communication.

PAYD As An Emission Reduction Strategy (USDOT 2010)
A Report To Congress produced by the U.S. Department of Transportation on potential transportation emission reduction strategies ranked distance-based insurance as one of the most effective, and by far the most cost effective way to reduce energy consumption and pollution emissions out of several dozen evaluated.

Conclusions

This study investigates the feasibility, benefits and costs of distance-based (or pay-as-you-drive) vehicle insurance, how it can be implemented, and the experience where it has been implemented.

Considerable research indicates that annual crash rates and claim costs tend to increase with annual vehicle mileage. Annual mileage is one of several factors that have a significant impact on annual crash rates. It would not be actuarially accurate to use mileage *instead* of other rating factors, for example, to charge all motorists the same per-mile insurance fee, but actuarial accuracy improves significantly if annual mileage is incorporated *in addition* to existing rate factors. Any other price structure overcharges low-mileage motorists and undercharges high-mileage motorists within each price class.

Distance-based insurance reflects the principle that prices should be based on costs. It does not simply shift costs from one group to another. It gives consumers a new way to save money by returning to individual motorists the insurance cost savings that result when they drive less. This lets motorists limit their insurance costs by limiting consumption, as with most other consumer goods. Motorists who continue their current mileage would be no worse off on average then they are now (excepting additional transaction costs), while those who reduce their mileage could save money. These result in net savings to motorists and net benefits to society.

Distance-based insurance is technically and economically feasible. Several insurers have successfully implemented distance-based pricing programs. Distance-based pricing can help achieve several public policy goals, including actuarial accuracy, equity, affordability, road safety, consumer savings and choice, reduced traffic congestion, road and parking facility cost savings, and environmental protection. It can reduce the need for cross-subsidies currently required to provide “affordable” unlimited-mileage coverage to high-risk drivers.

Distance-based insurance can provide significant safety benefits. Because most crashes involve multiple vehicles, reduced vehicle mileage can cause a proportionally greater reduction in crash costs and insurance claims. Some types of distance-based insurance give higher-risk drivers an extra incentive to reduce mileage, and some give motorists an extra incentive to avoid higher risk travel conditions. As a result, each 1.0% reduction in total mileage caused by distance-based insurance can reduce total crash costs by 1.4% to 2.0%. Distance-based insurance could reduce total crashes by 15% or more.

Distance-based pricing can provide substantial benefits to lower-income motorists. Since annual vehicle mileage tends to increase with income, fixed-price insurance tends to cause lower-income motorists to subsidize the insurance costs of higher-income motorists within their rate class. Distance-based insurance pricing provides overall savings to lower-income motorists, and would allow some low-income households to insure a vehicle used for basic mobility that they currently cannot afford.

This study evaluated several distance-based pricing options:

1. *Mileage Rate Factor* (MRF) incorporates an annual mileage rate factor into the existing rate system. It is the easiest option to implement, but is constrained by the weight that can be placed on self-reported mileage estimates. Its travel impacts and benefits are small.

2. *Pay-at-the-Pump* (PATP) funds basic insurance coverage through a surcharge on fuel sales. It is not actuarially accurate because payments are based on vehicle fuel consumption, not risk factors. Less than half of insurance payments would be distance-based, and cross-border and illegal fuel purchases could be major problems. It causes a relatively large reduction in fuel consumption but modest reductions in vehicle travel, providing modest overall benefits. There would probably be little administrative cost savings because motorists would still need to pay registration fees and purchase optional coverage as they do now.

3. *Per-Mile Premiums* change the unit of exposure from the vehicle-year to the vehicle-mile, incorporating all existing rating factors. They require odometer audits to provide accurate mileage data, predicted to cost an average of $6 per vehicle-year. This could be mandatory or a consumer option. Per-Mile Premiums significantly improve actuarial accuracy and provide significant consumer savings, particularly to lower income households. Because they cause large vehicle travel reductions they provide large benefits. As a consumer option they are predicted to attract 25-50% of motorists within a few years, and more over time.

4. *Per-Minute Premiums* use a small electronic meter to record when an engine operates, predicted to cost $30 per year. This allows rates to vary by time of day. Because it can give motorists an extra incentive to reduce their peak-period travel it can provide even greater benefits than Per-Mile Premiums, but the additional equipment costs reduce the net benefits. As a consumer option it is predicted to attract 12-25% of motorists within a few years.

5. *GPS-Based Pricing* uses GPS (Global Positioning System) technology to track vehicle travel, allowing insurance prices to reflect when and where a vehicle is driven in addition to existing rating factors. It is predicted to cost $150 or more per vehicle-year and raises privacy concerns. Installation costs may decline somewhat in the future as more vehicles have factory-equipped GPS transponders. It is most actuarial accurate and can cause the greatest crash reduction per participating vehicle. However, its high equipment costs offset the direct benefits for most consumers. As a consumer option it is predicted to attract 10% or less of total motorists, so total benefits would be modest for the foreseeable future.

Table 22 summarizes the implementation costs and effectiveness at achieving various objectives for the seven distance-based pricing options considered in this study.

Table 8 **Summary of Distance-Based Pricing Options**

	Implementation Costs	Effectiveness
Mileage Rate Factor	Low	Low
Pay-At-The-Pump	High	Medium
Per-Mile Premiums, Mandatory	Low	High
Per-Mile Premiums, Optional	Low	Medium
Per-Minute Premiums, Mandatory	Medium	High
Per-Minute Premiums, Optional	Medium	Medium
GPS-Based Pricing	High	Low

This table summarizes overall implementation costs and effectiveness at achieving objectives.

This analysis indicates that Mandatory Per-Mile Premiums provide the greatest net benefits, due to relatively low costs and high effectiveness at achieving objectives (Parry 2004 and Babiuk 2008 reach similar conclusions). It provides direct financial savings and net benefits to most motorists, and less than one in five would perceive significantly higher insurance costs. These benefits increase further if vehicle registration fees are also mileage-based. Optional distance-based pricing results in greater direct consumer benefits per participating vehicle, but smaller total benefits due to low market penetration and the low average mileage of motorists who would choose it. However, market penetration is predicted to increase over time as it becomes more financially attractive compared with fixed-rate premiums.

Because Per-Minute Premiums and GPS-Based Pricing provide an extra incentive to reduce peak-period driving they can provide extra congestion and pollution reduction benefits. This might justify partial subsidy of these options, depending on the value placed on these incremental benefits. However, more research is needed to evaluate the incremental costs, travel impacts, and social benefits.

Distance-based insurance pricing has two different types of effects on consumers. It provides savings to motorists who currently drive less than their price-group average, which represents a reduction in their current cross-subsidies to higher-mileage motorists within their price group. These are economic transfers that are justified on equity grounds. In addition, there are overall savings and benefits that result as motorists reduce their mileage, which reduce total crash costs, insurance costs, congestion, road and parking facility costs, and environmental impacts. These are resource cost savings, which are justified on economic efficiency grounds.

There is likely to be strong support for *optional* distance-based insurance pricing since it increases consumer choice and gives individual motorists a new opportunity to save money. Consumers are accustomed to being able to choose from various rate structures for many types of goods, such as telephone service, Internet service, and air travel. If cross-subsidies are not allowed between the different pricing pools, an increasing portion of motorists would switch to it over time.

There is mixed public support for *mandatory* distance-based insurance. Citizens generally support pricing that increases fairness and affordability, and helps solve specific problems, but are skeptical of reforms that may be less convenient, increase costs, or burden certain groups. PATP appears to be the least popular option. Usage-Based Premiums appears to have about equal levels support and opposition, with responses affected by the concept is presented. If described as a reward to consumers who use alternative modes it tends to have a positive response, but if presented as a surcharge on higher-mileage motorists it tends to have a more negative response.

Under some circumstances consumers seem to prefer fixed prices, because they are predictable and minimize transaction costs. However, this preference appears to be weak. Fixed-rate pricing is relatively uncommon in competitive markets, and some markets are shifting toward more marginal pricing. There is no evidence that consumers have a strong preference for fixed-priced insurance. Given the choice, most motorists who expect to save money would probably choose optional distance-based insurance.

Many of the concerns raised about distance-base pricing reflect misunderstanding of the concept, and so can be addressed with public education. Insurers have five legitimate financial concerns about distance-based insurance.

1. It is possible that the mileage foregone will be lower than average risk. As a result, premium revenue could decline more than claim costs.
2. Optional distance-based pricing could attract motorists with relatively high per-mile claim costs.
3. With optional distance-based pricing, motorists in multi-vehicle households could shift driving from vehicles with distance-based premiums to those with fixed premiums.
4. Total premiums would probably decline, assuming distance-based pricing is successful at reducing claims. Although revenue reductions would be offset by reduced claim costs, this would reduce investment income, which could reduce insurance company profits.
5. Some motorists may try odometer fraud to steal insurance. However, odometers are increasingly tamper-resistant, and most types of fraud could be detected during annual audits and crash investigations. Odometer auditing should provide data comparable in accuracy to that used in other common commercial transactions.

Offsetting these financial risks is the fact that a percentage reduction in mileage usually provides a proportionally greater reduction in claims. Available empirical evidence suggests that each 1% reduction in mileage typically causes a 1.4-1.8% reduction in claims, making insurers financially better off. This increases the net savings from distance-based pricing and reduces the financial risks to insurers.

These concerns can be addressed by implementing distance-based pricing pilot projects to obtain information on feasibility, costs, consumer demand, travel impacts, crashes, and revenue impacts. These could start small, and if no major problems are encountered they could expand until all motorists are offered distance-based pricing.

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