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www.vtpi.org
Info@vtpi.org
250-360-1560

Distance-Based Vehicle Insurance As A TDM Strategy

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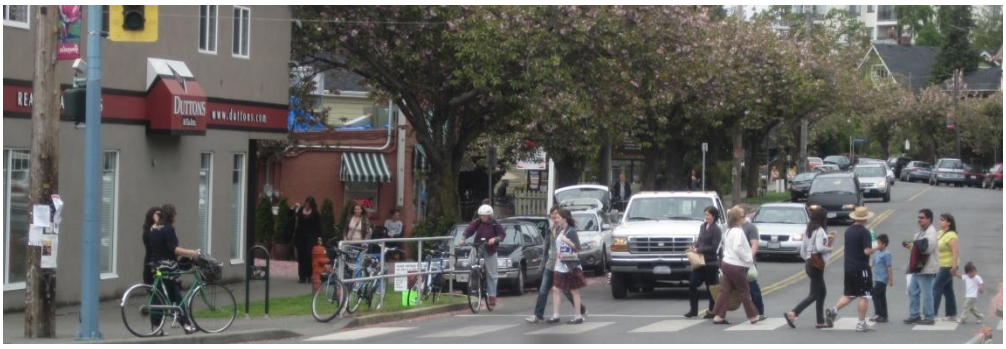
By Todd Litman
Victoria Transport Policy Institute



Abstract

Vehicle insurance is generally considered a fixed cost with respect to vehicle use: motorists seldom save on insurance by reducing their mileage. *Distance-based Vehicle Insurance* (DBVI, also called *Pay-As-You-Drive*, *Usage-based*, and *Per-Mile*) converts insurance to a variable cost, so premiums are based directly on annual vehicle-travel. This makes insurance pricing more actuarially accurate (premiums better reflect each vehicle's claim costs) and gives motorists a new opportunity to save money when they reduce their mileage and therefore risk exposure. It can help achieve several policy objectives including increased fairness, consumer savings and affordability, safety, congestion reduction, energy savings and emission reductions. This report compares several distance-based insurance pricing options, and evaluates concerns and criticisms. The analysis indicates that DBVI is technically and economically feasible, and can provide significant benefits to motorists and society.

What would be the consequences of selling gasoline 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 their company's fuel stations. Prices would be based on the average cost of supplying fuel to similar motorists. This would cause a spiral of increased fuel consumption, mileage and vehicle costs, including externalities such as accident risk, congestion and pollution. Motorists who use less fuel than average would find this unfair, but those who use more 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.

Introduction

This report explores the feasibility and potential benefits of implementing *distance-based vehicle insurance* (DBVI, also called *pay-as-you-drive, usage-based* and *per-mile*). Insurance is currently a fixed cost with respect to vehicle travel: marginal reductions in annual vehicle travel generally provide no insurance cost savings. Distance-based pricing converts insurance into a variable cost, so changes in annual vehicle travel provide comparable changes in premium costs.

Extensive research, described later in this report, indicates that, all else being equal (for a particular motorist or group), marginal changes in vehicle travel, what safety experts call risk *exposure*) cause comparable changes in crash rates. Of course, other factors affect a vehicle's crash risks so it would not be appropriate to charge all motorists the same per-mile fee, but insurance becomes more actuarially accurate (each vehicle's premiums more accurately reflect its crash costs) if annual mileage is incorporated with other rating factors, so for example, a typical motorist who currently pays $600 annually, would pay about 5¢ per mile, and a motorists who currently pays $1,800 annually would pay 15¢ per mile. Since average automobiles (cars and light trucks) are driven about 11,300 annual miles and are charged about $1,150 annually for insurance, DBVI would average about 10¢ per vehicle-mile (AFDC 2017; BLS 2016).

Distance-based insurance reflects the principle that prices should reflect costs. 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.

Motorist Reduces Mileage
⇩
Reduced Crashes
⇩
Insurance Cost Savings

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. Consider, for example, lower-income workers who become unemployed and so no longer commute. With current pricing they must continue paying the same premiums, although their mileage, crash risk and incomes decline. With DBVI, their reduced mileage reduces their premiums, but allows them to insure their vehicles for essential trips, temporary employment and job searches.

With distance-based pricing, motorists who continue driving average annual mileage pay the same as they do now, but those who reduce mileage save money. 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. Users 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, increasing their consumer surplus.

Distance-based insurance redefines insurance *affordability*: with current pricing affordability requires overcharging lower-risk drivers relative to their claim costs in order to reduce premiums for higher-risk drivers. With PAYD, affordability means that higher-risk motorists limit their mileage to what they can afford, which increases safety for all road users.

Distance-based insurance pricing can provide the following benefits:

- *Increased actuarial accuracy.* It makes 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 and therefore risk exposure. Since higher-risk motorists have a greater incentive to reduce mileage, and since most casualty crashes involve multiple vehicles, mileage reductions should provide proportionately larger reductions in crash injuries. Even motorists who do not reduce their mileage gain safety.
- *Vehicle travel reductions.* Reduced vehicle travel reduces traffic congestion, roadway costs, energy consumption, and pollution emissions.
- *Consumer savings and affordability.* It gives motorists a new opportunity to save money, which is particularly beneficial to lower-income motorists, who driver less on average and place a high value on saving money.
- *Reduced need for cross-subsidies*. Conventional insurance overcharges lower-risk drivers in order to keep unlimited-mileage coverage affordable to higher-risk, lower-income motorists.
- *Is progressive with respect to income.* Since average annual mileage per vehicle increases with income, most lower-income motorists should save money.

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

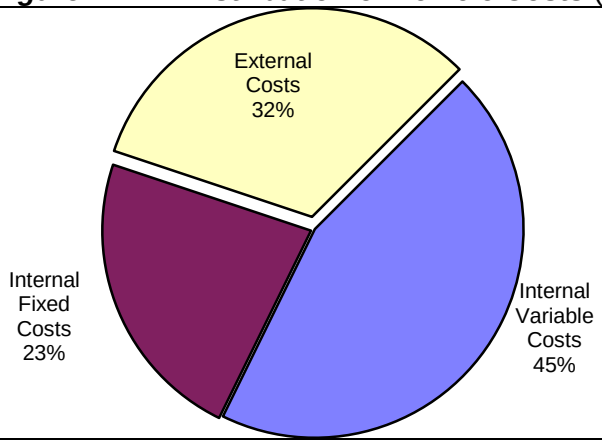
- It requires insurers and brokers to change how they calculate premiums, develop new procedures, and modify computer programs.
- When first implemented, insurers will face uncertainty as they develop actuarial experience with this rate structure.
- Some pricing systems increase transaction costs. Incremental 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

Current motor vehicle prices are economically inefficient, since prices do not reflect marginal costs. Nearly a third of vehicle costs are external and a quarter are internal but fixed, as illustrated in Figure 1.

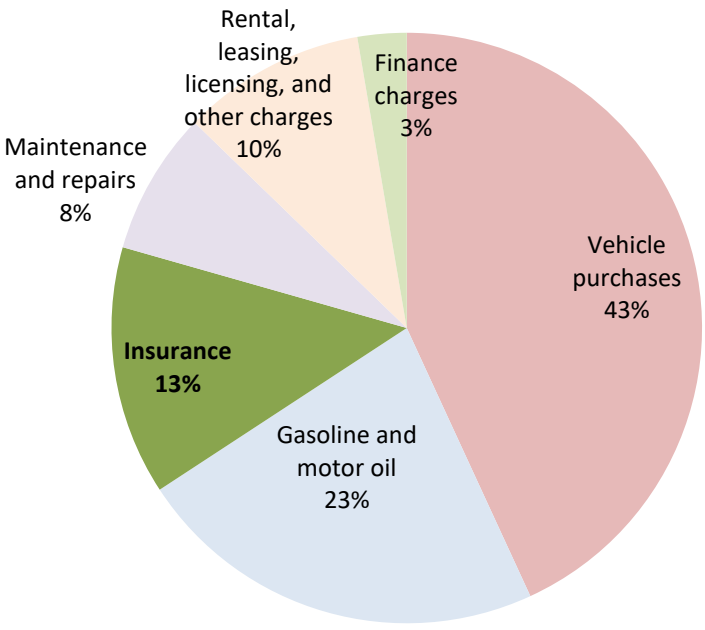
Figure 1 **Distribution of Vehicle Costs** (Litman 2009)



A majority of automobile costs are either fixed or external. Both are forms of underpricing, which is economically inefficient. Distance-based insurance makes premiums more accurately reflect each vehicles crash costs, and gives motorists a new opportunity to save money if they reduce their mileage, which is more economically efficient and fair than current pricing.

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. DBVI converts insurance into a variable cost, giving motorists more incentive to reduce lower-value vehicle trips.

Figure 2 **Distribution of Automobile Expenses** (BLS 2016)



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

Insurance is generally the second or third largest vehicle expense.

Relationships Between Vehicle Prices, Travel and Crashes

An extensive body of research has investigated how transportation prices (what users pay to travel) affect travel activity and crash rates (CARB 2014 Litman 2012 and 2017). The long-term elasticity of fuel consumption with respect to price is about –0.7 (a 10% price increase typically causes a 7% reduction in fuel use), but most of this results from motorists purchasing more fuel efficient vehicles; about one third reflects mileage reductions; a 10% fuel price increase typically reduces vehicle travel 2-3% (Goodwin, Dargay and Hanly 2004; Li, Linn and Muehlegger 2011).

Since North American automobiles currently average about 20 miles per gallon and gasoline prices average about $3.00 per gallon, motorists pay about 15¢ per mile for fuel. As previously described, fully-marginalized DBVI premiums (total premiums pro-rated by average mileage) average approximately 10¢ per vehicle-mile, which is equivalent to a $2.00 per gallon fuel tax, increasing vehicle operating costs approximately 66%, although it is not a new expense, simply a different way to pay an existing fee. A -0.2-0.3 elasticity of vehicle travel with respect to fuel prices, this should reduce affected vehicles' average annual mileage 10-15% over the long run.

Many studies using various methods and data sets indicate that, all else being equal, changes in vehicle travel, or what safety experts call "risk exposure," cause similar changes on crashes. Even a "perfect" driver faces risks from causes beyond their control—an animal running into the roadway, mechanical failure or medical crisis —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, reducing their annual mileage reduces their annual collision risk.

Since about 70% of crashes involve multiple vehicles, each 1.0% mileage reduction should reduce total crash costs by 1.7%.[1] Empirical evidence indicates that the elasticity of vehicle insurance costs with respect to mileage is between 1.42 and 1.85, so a 10% reduction in total vehicle mileage reduces total crashes, crash costs and casualties by 14% to 18% (Edlin 2003).

Per-mile crash rates tend to be low for high-annual-mileage drivers for reasons described below. Most of these factors do not change when an individual driver marginally reduces 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, these differences between different motorists do not necessarily apply to mileage reductions by individual motorists.

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.

[1] 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% (10% + 7%) reduction in crash risk.

Various studies find that at an aggregate level, higher fuel prices tend to reduce per capita traffic fatality rates. Ahangari, et al. (2014) employed a panel data model of 14 industrialized countries between 1990 and 2000 using gas prices, unemployment, health index, vehicle ownership and vehicle travel as independent variables and per capita traffic deaths as a dependent variable. The results revealed a significant inverse relationship between gas prices and the road fatality rates. The elasticity analysis indicates that a 10% decrease in gasoline prices resulted in a 2.19% increase in road fatalities.

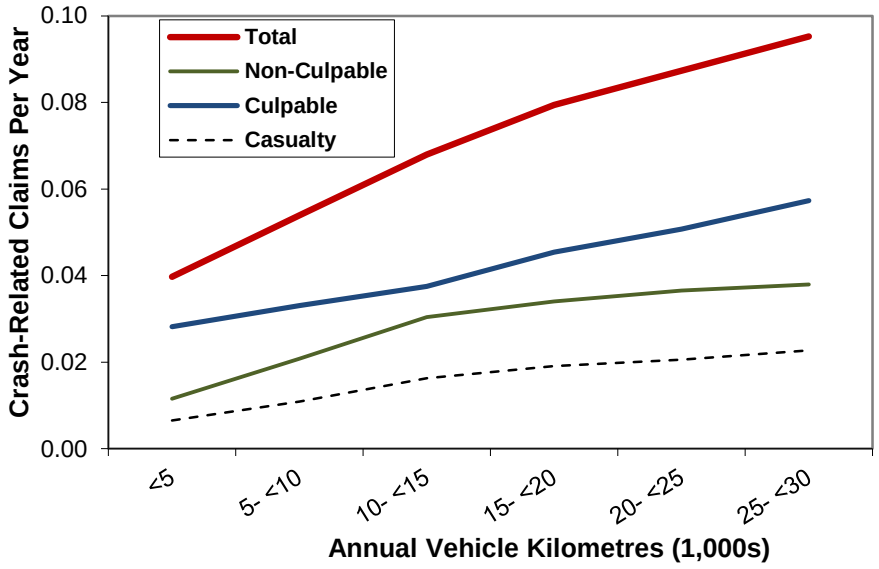
Using two decades of data for 144 countries, Burke and Nishitateno (2015), found that the average reduction in road fatalities resulting from a 10% increase in the gasoline pump price is in the order of 3-6%, and estimate that approximately 35,000 deaths per year could be avoided by the removal of global fuel subsidies. Morrisey and Grabowski (2011) find that a 10% U.S. fuel price increase reduces fatalities by 3.2–6.2% with the largest percentage reductions among 15- to 17-year-old drivers, and a 10% beer tax increase reduces motor vehicle fatalities by 17-24 year old drivers by approximately 1.3%.

Studies by Chi, et al. (2010a, 2010b, 2011 and 2013, 2015) measure fuel price impacts on traffic crashes in various U.S. regions. Fuel price increases reduce both total crashes and distance-based crash rates (e.g., per million vehicle miles traveled), with impacts that tend to increase over time. All these studies show that fuel price increases reduce per-mile crash rate, so a 1% reduction in total VMT provides more than a 1% reduction in total crashes. For example, controlling for other risk factors (total vehicle travel, seatbelt use, state unemployment and alcohol consumption), in Mississippi they find that each 1% inflation-adjusted gasoline price increase reduces total (all types of drivers) crashes per million vehicle-miles traveled 0.25% in the short-run (less than one year) and 0.47% in the medium-run (Chi, et al. 2010a).

These previously-described studies reflect aggregate impacts. In recent years, data have become available on the relationships between vehicle travel and crash rates for individual vehicles. Using Progressive Insurance Corporation data, Bordoff and Noel (2008), found a strong positive relationship between mileage and claims. A major study that matched annual mileage and insurance claim cost data for 2.8 million vehicle-years found that, all else being equal, as mileage increases so do vehicles' chances of having crashes and insurance claims (Ferreira and Minike 2012). Using a large Spanish data set, Boucher, Pérez-Marín and Santolino (2013) found a strong positive relationship between vehicle travel and claim frequency under 10,000 annual kilometers, but a weaker relationship for higher mileages, which they hypothesize reflect more highway driving by higher-annual-kilometer vehicles. Overall, these studies confirm the actuarial soundness of PAYD pricing.

Figure 3 illustrates the relationship between annual vehicle-kilometers and crash rates using several million vehicle-years of British Columbia data. The positive relationship between annual mileage and crashes applied to virtually all rate categories.

Figure 3 **Crash Rates by Annual Vehicle Mileage** (British Columbia Data)



British Columbia data shows that annual crashes tend to increase with annual kilometres at the aggregate level.

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 1 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 1 **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) *(Edlin 2003;* Bordoff & Noel 2008; Ferreira & Minikel 2010*)*

This means that vehicle insurance is sold by the vehicle-mile (or kilometer) rather than the vehicle-year.[2] 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.

[2] 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.

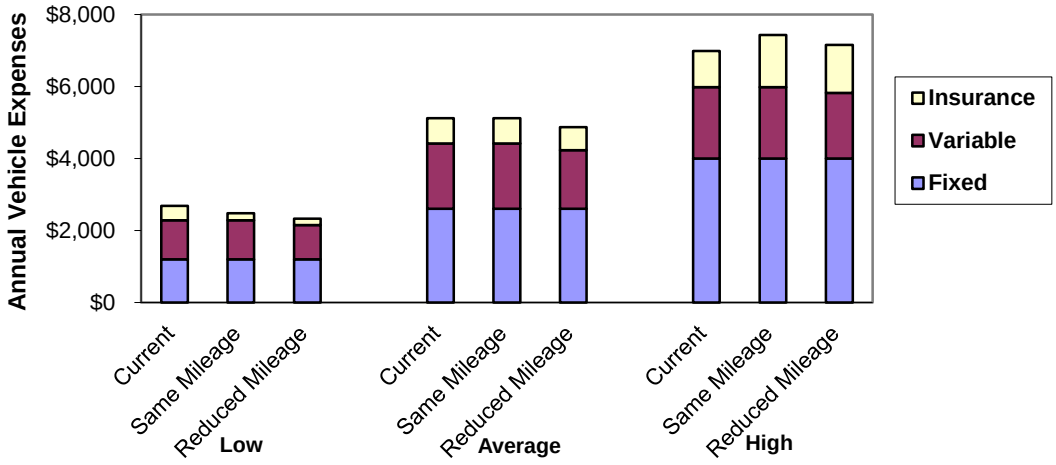
Audits take 5-10 minutes and less if performed with other vehicle servicing, and so are estimated to cost $5-10 per vehicle-year. Governments could certify auditors and incorporate odometer data into their vehicle registration database, or insurance companies could establish their own auditor networks. 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.[3]

Figure 4 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 4 **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.

[3] 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.[4] 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.[5] 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 2 **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.

[4] The Progressive Insurance Company's U.S. patent number 5,797,134 covers this technology.

[5] *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.[6]

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 3 indicates the magnitude of these per-mile costs, and the effects on vehicle travel, based on standard elasticity values. Figure 5 illustrates the travel reductions.

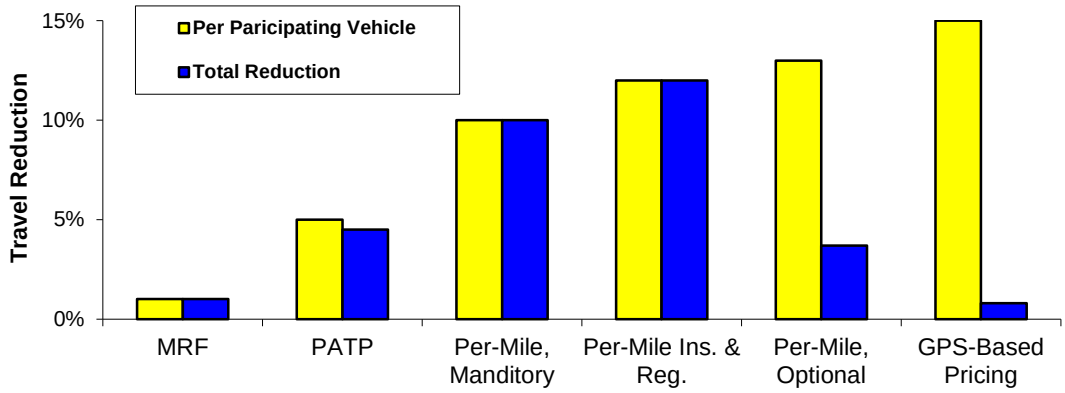
Table 3 **Travel Reduction Impacts**

	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.

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

Figure 5 **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 4 **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.

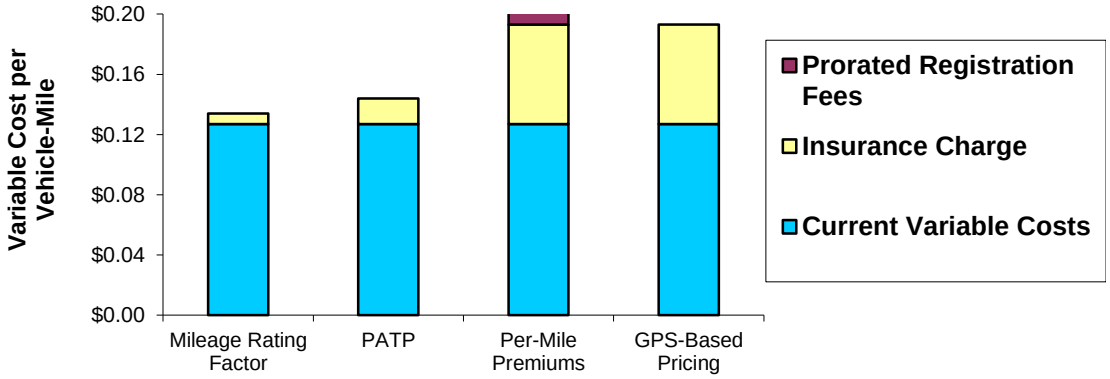
6. Congestion and Facility Cost Savings

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 6 illustrates the increased variable costs from different distance-based insurance pricing options. Figure 7 illustrates impacts on total vehicle costs, which are modest because insurance is a minor portion of total vehicle costs.

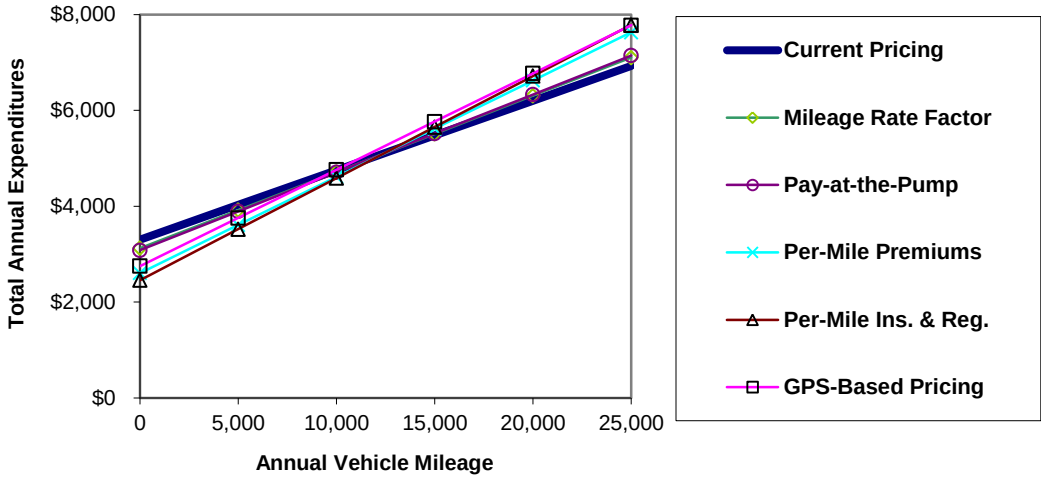
Figure 6 **Impacts On Variable Vehicle Costs**



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 7 **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 (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.

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

Table 5 **Impact Rating Summary**

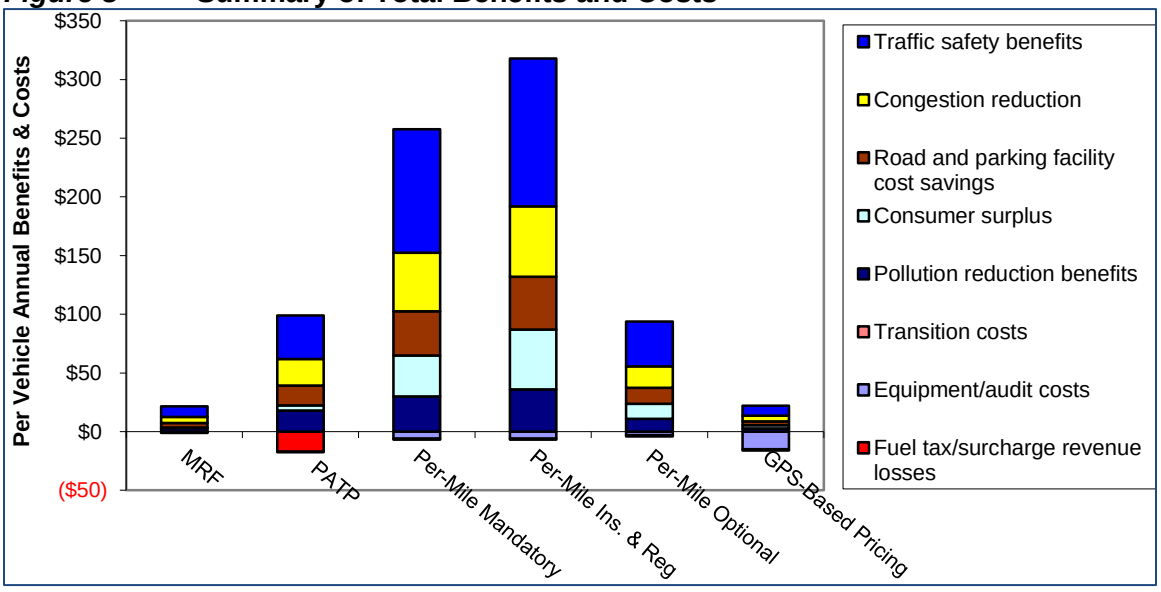
	MRF	PATP	Per-Mile Mandatory	Per-Mile Ins. & Reg.	Per-Mile Optional	GPS-Based
Actuarial Accuracy	1	0	2.5	2.5	2.5	3
Implementation Costs	-1	-3	-1.5	-1.5	-1	-3
Fairness	1	0	2.5	2.5	2.5	3
Progressive	1	-1	2.8	3	3	1
Consumer Impacts	1	2	3	3	3	1
Public Acceptability	1	0	2	2	3	1
Travel Impacts	1	2	2.8	3	2	1
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 8 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 8 **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 these savings; they assume that the savings represent cost shifts, so each dollar of savings to motorists who save requires an additional dollar paid by other motorists. This is untrue. Much of the savings reflect insurance cost reductions provided by reductions in crashes and therefore claim expenses. 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.

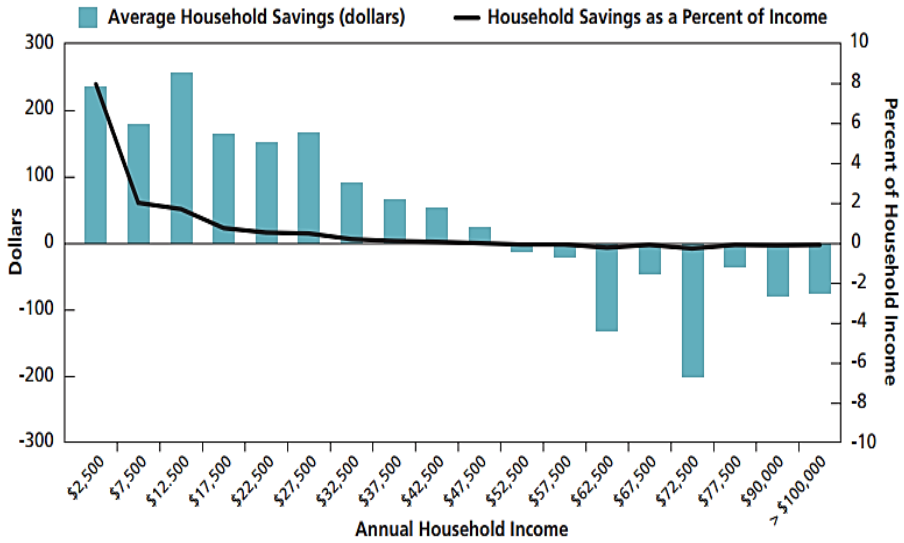
Since DBVI offers a new opportunity for savings, the mileage reductions provide consumer benefits. For example, if a motorist who shifts to distance-based insurance with 10¢ per vehicle-mile premiums responds by reducing their vehicle travel 10%, or 1,200 annual vehicle-miles, as models predict, we can 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, the average consumer surplus (net consumer benefit) is calculated as the mid-point of this range, that is, 5¢ per vehicle-mile. Thus, 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 5¢ per mile).

Under many 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.

Since lower-income motorists tend to drive their vehicles less than average and are particularly responsive to savings opportunities, PAYD tends to be progressive with respect to income. One major study found that PAYD provides savings to 64% of all households and almost 80% of low-income households, averaging $496 annually per household that saves (Figure 9). More than half of all rural residents would save money, and because they have high traffic casualty rates they enjoy particularly large safety benefits.

Figure 9 **Estimated PAYD Savings by Household Income** (Bordoff and Noel 2008)



Because lower-income motorists tend to drive less and are particularly responsive to money saving opportunities, PAYD insurance tends to be progressive with respect to income: lower-income motorists save more than higher incomes motorists.

Responses to Concerns about DBVI

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 are 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 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 small crash reduction and savings.
This concern is technically possible but 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 lower-income motorists, including those who currently drive less than average or would drive less than average in response to this new opportunity to save money, plus those who currently drive uninsured because they cannot afford insurance or cannot afford to own an automobile due to high insurance costs. Fixed insurance pricing causes premiums and uninsured driving rates to increase harming low-income communities (Butler 2000).

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 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, odometer auditing should discourage tampering, and the financial incentive for fraud is relatively low. Insurers' financial exposure would be minimal since 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 and 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 other information considered private. Odometer readings are already collected during vehicle servicing, vehicle sales and crash investigations. Odometer auditing simply standardizes the collection of this information. 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 data are processed, stored and used, as with other personal data such as telephone calls and credit card transactions.

Table 6 **Obstacles and Potential Solutions**

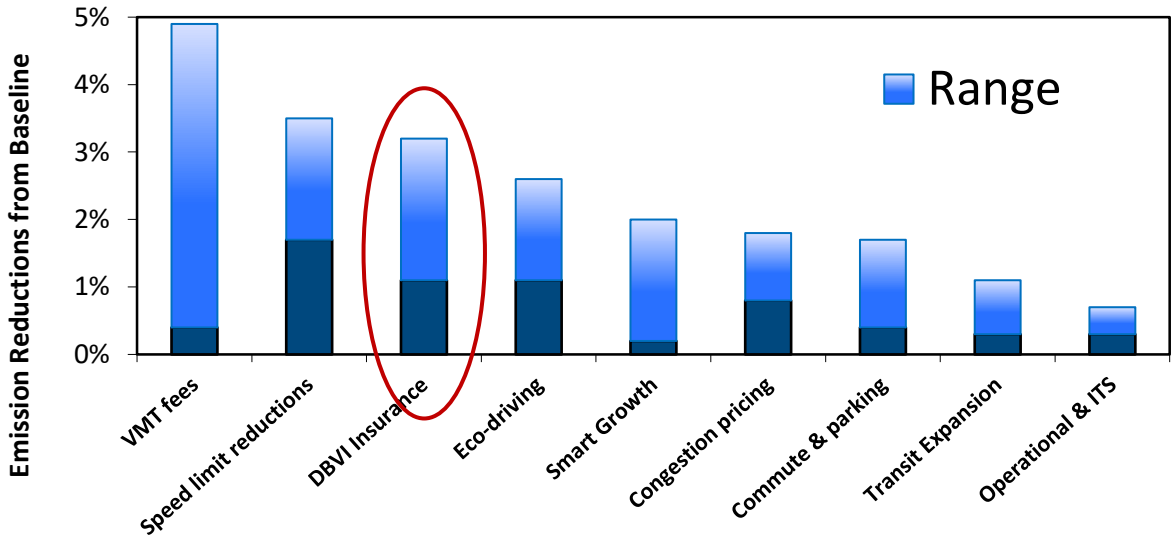
Obstacle	Potential Solutions
Misunderstandings. Many objections to DBVI pricing reflect misunderstandings of the concept. Some people believe it refers to Pay-At-The-Pump (insurance coverage funded through a fuel sales surcharge), are unaware of its full potential benefits, or have exaggerated estimates 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 projects using a basic prorated premium (current 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.

Potential Energy Savings and Emission Reductions

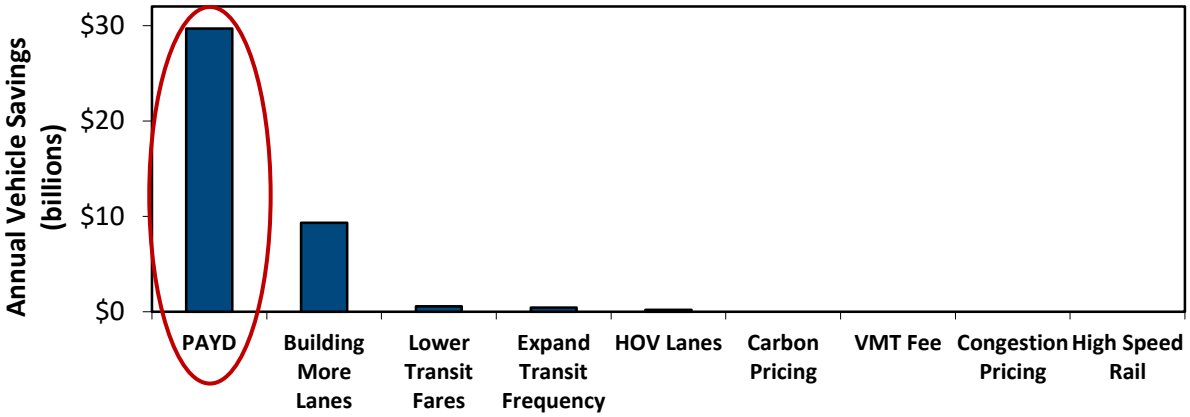
Several studies have evaluated potential energy savings and emission reductions of various strategies, including DBVI. A major U.S. federal study estimated that, if applied widely, DBVI could reduce transportation GHG emissions by 3% or more in 5-to-10 years (USDOT 2010). The report, *Moving Cooler* (Cambridge Systematics 2009) ranked DBVI as the third most effective and first most cost-effective of approximately 50 strategies considered (Figures 10 and 11).

Figure 10 **Potential Emission Reductions Compared** (Cambridge Systematics 2009)



Of approximately 50 strategies considered, DBVI ranked third in potential emission reductions.

Figure 11 **Potential Emission Reductions Compared** (Cambridge Systematics 2009)



DBVI ranked first in net consumer savings (fuel savings minus incremental costs).

Similarly, analysis by Greenberg and Evans (2017) concluded that distance-based vehicle insurance and taxes (existing fixed vehicle taxes converted into distance-based taxes) could reduce 140-257 million metric tons of carbon dioxide equivalent annually, equal to 37-69% of the Clean Power Plan reductions, or 3.3-6.1 times the reductions of a nationwide transportation fuels cap-and-trade program with a $50 per ton permit price, as a fraction of the costs.

Examples and Case Studies

Metromile (www.metromile.com)

Metromile currently offers PAYD insurance in Arizona, California, Illinois, New Jersey, Oregon, Pennsylvania, Virginia, and Washington. Premiums are billed monthly, including a low base rate plus cents per mile driven, based on the *Metromile Pulse* wireless device that reports the previous month's mileage. For analysis see *Metromile Review: Will Pay-Per-Mile Save You Money?* (Butsch 2020).

CAA MyPace (www.caamypace.com)

The Canadian Automobile Association's *MyPace* policies offer substantial (20-70%) savings for vehicles driven less than 10,000 annual kilometers in Ontario. Vehicle travel is measured using a small wireless device that plugs into a vehicle's OBD-II port. Motorists are billed for each 1,000 kilometers driven.

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 recognize 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.

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 Pricing Product Rating

Some PAYD products provide greater benefits than others. To minimize confusion and maximize benefits the Ceres coalition of insurance companies and environmental organizations developed a PAYD rating system similar to *LEED Building* and the *Energy Star* standards. (Ceres 2009)

Four factors are considered in the proposed ratings:

1. *Mileage band size (smaller is better).* Many policies use 100, 500, or 1,000 mileage bands. The smallest mileage band is a single vehicle-mile or kilometer.
2. *Minimum number of miles motorists must purchase (smaller is better).* This insures that policy transaction costs are repaid even for vehicles driven very low annual miles.
3. *Percentage reduction in total premiums provided by a 50% reduction in annual mileage (larger is better).* This is based on the percentage reduction in total annual premiums (including optional coverages such as fire and theft) provided by a reduction from 12,000 to 6,000 annual miles (from 6,000 to 3,000 miles for a six-month policy).
4. *If unit prices vary between mileage bands, maximum difference between highest and lowest prices in a policy (smaller is better)*. For example, for a particular policy the first 5,000 annual miles could be priced at 10¢ per vehicle-mile, the second 5,000 at 8¢ per vehicle-mile, the third 5,000 miles at 6¢ per vehicle miles, and miles over 15,000 annual miles at 5¢ per vehicle-mile. In this case the maximum difference is two, since 10¢ is twice 5¢.

The ratings are:

Gold

Premiums are priced by the vehicle-mile, incorporating all existing rating factors. A 50% mileage reduction provides at least a 50% premium reduction. Insurers may require up to 2,000 annual miles purchased. Unit prices may not vary by more than a factor of two.

Silver

Maximum bands of 250 miles of driving. A 50% mileage reduction provides at least a 40% premium reduction. Insurers may require the purchase of up to 3,000 annual miles. Unit prices may not vary by more than a factor of 2.5.

Bronze

Maximum bands of 500 miles of driving. A 50% mileage reduction provides a 25% premium reduction. Insurers may require the purchase of up to 4,000 annual miles. Unit prices may not vary by more than a factor of 3.0.

Table 8 **Rating Summary**

Rating Factors	Gold	Silver	Bronze
Maximum mileage bands used for pricing	1	250	500
Maximum annual miles that must be purchased	2,000	3,000	4,000
Percentage premium reduction from a 50% mileage reduction	50%	40%	25%
Maximum difference between lowest to highest price unit	2	2.5	3

This table summarizes minimal performance requirements for PAYD ratings.

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, returns to individual motorists the insurance cost savings that result when they drive less. This lets motorists reduce their insurance costs by reducing their 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 currently use it. DBVI can help achieve several public policy goals including increased fairness, affordability, consumer savings and choice, road safety, reduced traffic congestion, road and parking facility cost savings, and environmental protection. It reduces 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 DBVI gives higher-risk drivers an extra incentive to reduce mileage, and because most casualty crashes involve multiple vehicles, it tends to proportionately greater reduction in crash costs and insurance claims, so each 1.0% reduction in total mileage will reduce total crash and casualties by 1.4% to 1.8%. As a result, if widely applied DBVI could reduce total crashes by 15% or more.

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 fairness 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.

Distance-based pricing tends to be particularly beneficial to lower-income motorists. Since annual vehicle mileage tends to increase with income, fixed-price insurance is regressive with respect to income: it causes 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. *Usage-based Premiums* use a small electronic meter to record when, how and how much a vehicle is used. It is predicted to cost approximately $30 per year for equipment and data management. It can give motorists an extra incentive to reduce higher-risk driving, and so can provide 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.

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

Table 9 **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
Usage-based Premiums, Mandatory	Medium	High
Usage-based 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 total 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 should increase over time as it becomes more financially attractive compared with fixed-rate premiums.

Because Usage-based Premiums and GPS-Based Pricing provide an extra incentive to reduce higher-risk driving they can provide extra congestion and pollution reduction benefits. This might justify partial subsidy of these options, but more research is needed to evaluate the incremental costs, travel impacts, and social benefits.

There is likely to be strong public 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 price structures for many types of goods, such as telephone service, Internet service, and air travel. If cross-subsidies are not allowed between 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 concerns raised about distance-based 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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