Pricing for Traffic Safety

How Efficient Transport Pricing Can Reduce Roadway Crash Risks

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This paper evaluates the traffic safety impacts of various transport pricing reforms, including fuel-tax increases, efficient road and parking pricing, distance-based insurance and registration fees, and public-transit fare reductions. This analysis indicates that such reforms can significantly reduce traffic risk, in addition to providing other important economic, social, and environmental benefits. Crash reductions depend on the type of price change, the portion of vehicle travel affected, and the quality of alternative transport options available. If implemented to the degree justified on the grounds of economic efficiency (for example, to reduce congestion, recover road and parking facility costs, and make insurance more actuarially accurate), these reforms are predicted to reduce North American traffic casualties by 40% to 60%. The low per capita traffic fatality rates in European and wealthy Asian countries result in significant part from their higher transport prices, which result in more efficient multimodal transport systems by which residents drive less and rely more on alternative modes. However, these benefits are often overlooked: pricing reform advocates seldom highlight traffic safety benefits, and traffic safety experts seldom advocate pricing reforms. Taking these steps is particularly important for developing countries now establishing pricing practices that will affect their future travel patterns and therefore crash risks.

Traffic safety is an important transport planning objective. Traffic accidents cause millions of disabilities and deaths, and hundreds of billions of dollars in economic costs annually worldwide (*1, 2*). As a result, safety is a paramount consideration in roadway design and operation, and many motorists willingly pay a premium for optional safety features. Experts continually search for new ways to increase traffic safety (*3, 4*).

Many factors affect traffic risk, including the amount and type of travel activity, roadway and vehicle type, and driver behavior. One significant factor is transportation pricing, the fees and taxes charged to travel. Transport pricing reforms include increased fuel prices, more efficient road and parking fees, distance-based insurance and registration fees, and reduced public transit fares. These pricing reforms are advocated to help agencies achieve various planning objectives, including congestion reduction, revenue generation, equity, affordability, energy conservation, and pollution reduction (*5*). The analysis described in this report indicates that these reforms can also provide significant traffic safety benefits. However, safety impacts are often overlooked in both the evaluation of pricing reform benefits and in the search for cost-effective traffic safety strategies. As a result, implementation of such reforms is less than optimal.

The current traffic risk paradigm (the basic assumptions used to define a problem and evaluate possible solutions) tends to overlook pricing as a traffic safety strategy because it assumes that traffic crashes result primarily from special risks, such as drunk and distracted driving, unsafe vehicles, and poorly designed roadways. That paradigm considers normal vehicle travel (a responsible, sober driver wearing seatbelts in a modern car driven on a well-designed highway) a safe activity that need not be reduced. From this perspective, transport price increases are an inefficient and unfair way to increase safety because they punish all motorists for risks caused by a minority. The current paradigm tends to measure risk by using distance-based indicators (such as fatalities per 100,000 vehicle miles) and therefore does not recognize the incremental risks of policies that induce additional vehicle travel and the safety benefits resulting from policies that reduce vehicle travel.

A new traffic safety paradigm recognizes that all vehicle travel carries risk. Even perfect drivers who never violate traffic rules marginally increase accident risk by increasing mileage because of hazards beyond their control (e.g., a medical problem or mechanical failure), because their presence on a roadway makes them vulnerable to another drivers' errors and because most drivers take incremental risks, such as traveling a little faster than necessary for optimal safety. Conversely, virtually any reduction in mileage provides marginal safety benefits.

This article investigates these impacts. It describes various ways to measure traffic risks and how they influence the perceived safety benefits of mobility management strategies, such as pricing reforms; evaluates the crash reductions of various pricing reforms; describes the impacts of pricing reforms on consumers; and discusses the role that pricing reforms can play in achieving traffic safety objectives. This article summarizes a more detailed report on this subject (*6*).

RISK EVALUATION

Traffic crashes (also called accidents or collisions) can be measured in various ways that lead to quite different conclusions about their risks and the effectiveness of various safety strategies. For example, Figure 1 illustrates two ways to measure traffic fatality rates. When measured per unit of travel (e.g., per 100 million vehicle miles), fatality rates declined by more than two-thirds during the last four decades. From this perspective, past traffic safety programs were successful

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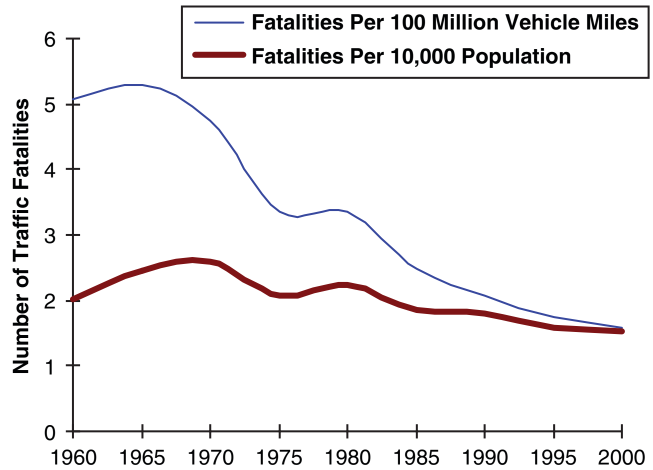

FIGURE 1 U.S. traffic fatalities. (Source: U.S. Bureau of Transportation Statistics.)

and should be continued. But per capita vehicle mileage more than doubled during that period, offsetting much of this decline. When measured per capita (e.g., per 10,000 population), as with other health risks, fatalities rates showed little improvement despite large investments in safer road and vehicle designs, increased use of safety devices, targeted traffic law enforcement, and better emergency response and medical care. When these factors are taken into account, much greater casualty reductions could be expected (*7*). For example, seat belt use increased from nearly 0% in 1960 to 75% in 2002, which should reduce traffic fatalities about 33%, yet per capita traffic fatalities declined only 25% because reduced risk per mile was offset by increased mileage.

International data indicate that per capita traffic fatality rates tend to decline as countries develop economically and per capita vehicle travel increases; these data imply that mileage is not a risk factor, but comparisons between otherwise-comparable countries and regions indicate that per capita traffic casualty rates increase with vehicle travel (*8, 9*). For example, Figure 2 shows a strong positive relationship between per capita vehicle travel and traffic fatalities among countries in the Organisation for Economic Co-operation and Development (OECD), which includes most major economically developed countries. Similarly, comparisons between U.S. states indicate a strong positive relationship between per capita vehicle travel and per capita traffic fatality rates, as illustrated in Figure 3.

The relationship between risk and mileage is particularly strong for motorists who marginally reduce their mileage, because most risk factors do not change with less driving (*10*). For example, a motorist who reduces mileage 20% in response to a price incentive does not usually become more hazardous. Sivak and Schoettle found that the 14% decline in U.S. traffic crashes between 2005 and 2008 is largely explained by reductions in per capita vehicle travel (*11*). Reductions in total vehicle travel can cause proportionally larger reductions in total crash damages because about 70% of crashes involve multiple vehicles, so each vehicle removed from traffic reduces both its chances of causing a crash and of being the target of crashes caused by another vehicle, and reducing multivehicle crashes reduces multiple claims (*12*).

Traffic safety experts often emphasize that most crashes are associated with special risk factors (young and inexperienced drivers, impairment, distraction, speeding, etc.); this assertion implies that safety programs should target risky travel and need not reduce low-risk vehicle travel (*3, 4*). But high- and low-risk travel are complementary; policies that stimulate lower-risk driving also tend to stimulate higher-risk driving. For example, where driving is inexpensive and convenient, reducing high-risk driving tends to be difficult because most destinations are conveniently accessible only by automobile and alternative modes are inferior and stigmatized. As a result, teenagers, drunks, and mentally impaired people continue to drive. Described more positively, policy reforms that reduce overall vehicle travel usually provide significant traffic risk reductions.

IMPACTS OF PRICING REFORM ON SAFETY

The prices individuals pay to use vehicles, roads, parking facilities, fuel, and public transit affect how and how much people travel, particularly in the long run (*13, 14*). During the last quarter of the

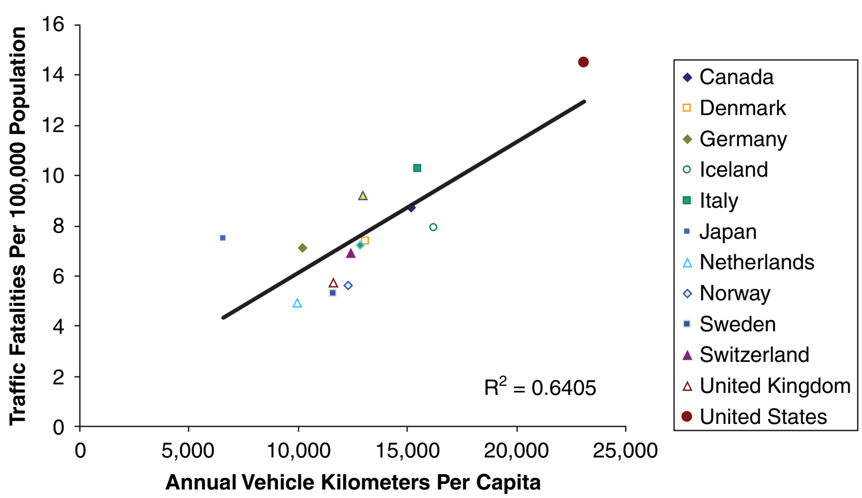

FIGURE 2 Vehicle mileage and traffic fatality rates in OECD countries. (Source: *OECD Factbook*, 2010.)

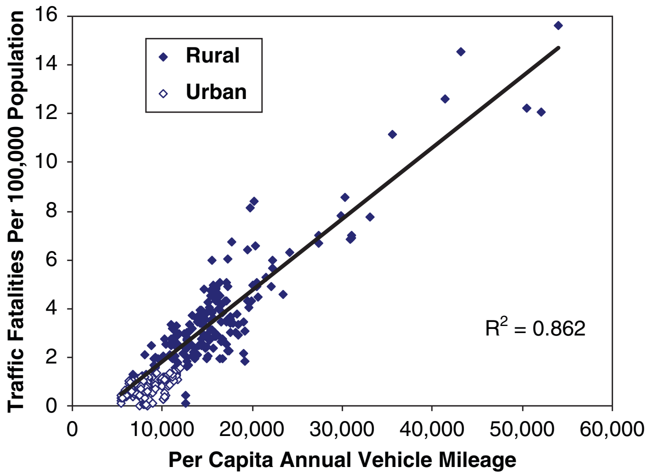

FIGURE 3 U.S. traffic fatality and mileage rates, 1995–2002 (each point = urban or rural portion of one U.S. state). (Source: FHWA, U.S. Department of Transportation.)

20th century, U.S. motor vehicle travel became less price sensitive, with elasticities estimated below –0.1 (*15*), but this was a unique period of increasing vehicle travel demands, increasing incomes, automobile-oriented transport and land use planning, and declining real fuel prices. Recent studies indicate that vehicle travel has since increased (*16, 17*). Travel impacts tend to be greater if prices increase relative to consumer wealth (for example, if fuel prices increase relative to median incomes) and with improved transport options (such as better public transit services or telework opportunities) (*14*). The remainder of this section evaluates the travel and safety impacts of specific price reforms.

Fuel Tax Increases

Justifications

Fuel tax increases are often recommended to finance roadway facilities and other transportation improvements and to encourage fuel conservation to achieve various economic and environmental objectives, including energy security and emission reductions (*18, 19*).

Travel Impacts

The long-term elasticity of fuel consumption with respect to price is about –0.7, so a 10% price increase causes a 7% reduction in fuel use; about two-thirds of this reduction results from consumers purchasing more fuel-efficient vehicles and about one-third from vehicle mileage reductions, so a 10% fuel price increase typically reduces mileage 2% to 3% in the long run (*13, 14*).

Safety Impacts

Various studies indicate that fuel price increases tend to reduce traffic fatality rates. Figure 4 indicates that among OECD countries, per capita traffic fatality rates decline with higher fuel prices. Sivak found that a 2.7% vehicle travel decline caused by high fuel prices and a weak economy during 2007 and 2008 caused much larger month-to-month traffic fatality reductions of 17.9% to 22.1%, probably because of large reductions in vehicle travel by lower-income drivers (who tend to be young or old and therefore higher-than-average risk) and speed reductions to save fuel (*20*). Using U.S. data, Grabowski and Morrisey estimate that each 10% fuel price increase reduces total traffic deaths 2.3%, with larger declines for the 15-to-21-year-old age group (*21*). In follow-up research, they estimate that each one-cent increase in state gasoline tax reduces per capita traffic fatality rates 0.25%, including a 0.26% reduction in fatalities per vehicle mile (*22*). Leigh and Geraghty estimate that a sustained 20% increase in gasoline prices would reduce approximately 2,000 traffic crash deaths (about 5% of the total), plus about 600 air pollution deaths (*23*).

Chi et al. have presented several studies that quantify the impacts of fuel prices on crash reductions in various U.S. regions. They find that fuel price increases tend to reduce both total and distance-based crash rates so that each 1% reduction in total vehicle travel reduces crashes by more than 1%. For example, they find that, in the state of Mississippi and controlling for other risk factors (total vehicle travel, seat belt use, state unemployment, and alcohol consumption), each 1% increase in inflation-adjusted gasoline prices causes a 0.25% reduction in total (all types of drivers) crashes per million vehicle

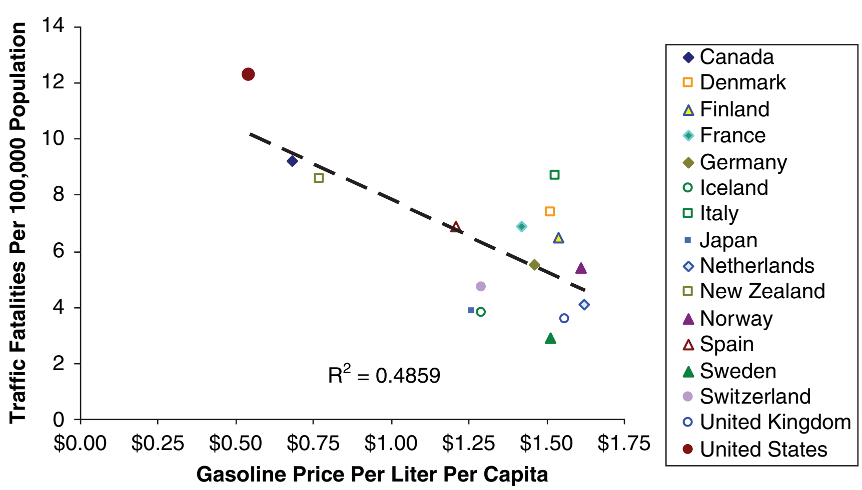

FIGURE 4 Fuel price and traffic fatality rates in OECD countries (*5*).

miles traveled in the short run, which approximately doubles to 0.47% after a one-year lag (*24*). Similarly, their analysis indicates that, in the state of Minnesota, a $1 increase in gasoline prices would reduce total rural crashes 28.15%, rural casualty crashes 3.9%, total urban crashes 18.40%, and urban fatal crashes 18.4%, holding other variables constant (*25*). They also find that fuel price increases (*a*) cause larger short-term crash reductions by younger drivers and larger intermediate-term reductions by older and male drivers (*26*) and (*b*) tend to cause particularly large reductions in drunk driving crashes (*27*).

Some debate exists about the safety impacts of more fuel-efficient vehicle fleets that result from higher fuel prices. Occupants of lighter vehicles face greater risk in crashes with heavier vehicles or stationary objects, but this result tends to be offset by the lower crash frequency, reduced risk to others, and safer designs of lighter vehicles (*28, 29*).

Road Pricing

Description

Road tolls and fees can be implemented to reduce traffic problems, to generate revenue, or both. Tolls are often used to finance new highways and bridges, and in some jurisdictions, revenues are used to finance regional transport improvement. Congestion pricing refers to road tolls and fees that are higher during peak periods and lower off peak to reduce peak-period traffic volumes and therefore congestion problems. In recent years, a few cities, including London, Singapore, and Stockholm, Sweden, have implemented congestion pricing systems, and the concept has been proposed in many other jurisdictions.

Travel Impacts

Road pricing typically reduces affected vehicle travel by 10% to 30%, but this reduction depends on price, facility type, and user types. In most jurisdictions, such tolls apply only to a minor portion of total vehicle travel (*14*).

Safety Impacts

Although research is limited, available data indicate that road pricing reduces crashes. The large cities that currently implement congestion fees tend to have low traffic fatality rates because of other factors, including low per capita vehicle travel and low traffic speeds. Within London's congestion charging zone between 2001 and 2004, vehicle travel declined by about 15%, but crashes declined by 28%, compared with a 22% regional decline in reported crashes during that period (*30*). Macrolevel collision prediction models that analyze crash rates at a fine geographic scale indicate that a typical congestion pricing program encouraging shifts to alternative modes is likely to reduce neighborhood collision frequency by approximately 19% (total) and 21% (severe) (*31, 32*).

Road pricing safety impacts will vary in relation to specific conditions and travel changes. Tolling of grade-separated highways could increase crash rates per mile if tolling shifts traffic to other roads. Because many tolled facilities (particularly bridges) have few alternative routes, however, the magnitude of this impact is probably small and offset by reductions in total vehicle travel. In most situations, tolling probably reduces total crashes.

Parking Pricing

Description

Parking pricing (in which motorists pay directly for using parking facilities) can be implemented to reduce parking congestion, generate revenue, or both. The potential for more-efficient parking pricing is considerable because currently most parking is unpriced, significantly subsidized, bundled, or rented by the month or year (which gives motorists little incentive to shift mode part time) (*33*).

Travel Impacts

Parking with cost-recovery pricing (prices that reflect the full costs of providing a parking facility) and parking cash out (offering nondrivers the cash equivalent of the parking subsidy that they would receive if they traveled by automobile) typically reduce vehicle travel by 10% to 30%, although impacts vary with conditions, including the type of trips and users affected, and the availability of alternative parking and travel options (*14, 34*).

Safety Impacts

Although little research specifically investigates the impacts of parking pricing on traffic safety, they are probably similar to those of road pricing. Because parking pricing is most commonly implemented in congested urban areas where crash rates are high, it is likely to provide large crash reductions. Because parking pricing could be widely applied, safety benefits are potentially large.

Distance-Based Pricing

Description

Distance-based (also called pay-as-you-drive) pricing converts vehicle insurance premiums and registration fees into variable costs so that a reduction in mileage provides significant financial savings (*7, 35*). The simplest approach, called basic pay-as-you-drive pricing, prorates premiums by mileage (premiums are divided by average annual mileage, so a $600 premium becomes $0.03 per vehicle kilometer, and a $2,000 premium becomes $0.10 per vehicle kilometer), on the basis of odometer readings collected at the start and end of the policy term. Other systems use electronic instruments installed in a vehicle to track the amount, and in some cases, when, where, and how the vehicle is driven.

Travel Impacts

With fully prorated vehicle insurance, average motorists would pay about $0.06 per vehicle kilometer, which is predicted to reduce their vehicle travel by 8% to 12%, and somewhat more if vehicle registration fees are also based on distance (*14*).

Safety Impacts

To the degree that distance-based pricing reduces vehicle travel, it reduces crashes. Crash reductions can be proportionally larger than mileage reductions for two reasons.

First, higher-risk motorists pay more per vehicle mile and so have a greater incentive to reduce mileage. For example, a low-risk driver who currently pays $360 in annual premiums would pay about $0.03 per vehicle mile and so would be expected to reduce mileage by only about 5%, but a higher-risk driver who pays $2,400 annual premiums would pay $0.20 per vehicle mile and so would be expected to reduce mileage by more than 20%. Some distance-based insurance systems set prices according to when, where, and how a vehicle is driven; such a method can provide additional safety benefits by discouraging particularly risky driving activity (*9*).

Second, because about two-thirds of traffic crashes involve multiple vehicles, large reductions in vehicle travel can reduce risk both to the motorists who reduce their mileage and to other road users (*8, 12*). As a result, if fully implemented in an area, distance-based pricing can reduce traffic crashes by 12% to 15%, and possibly even more, depending on price structure and other factors, such as the quality of transport options.

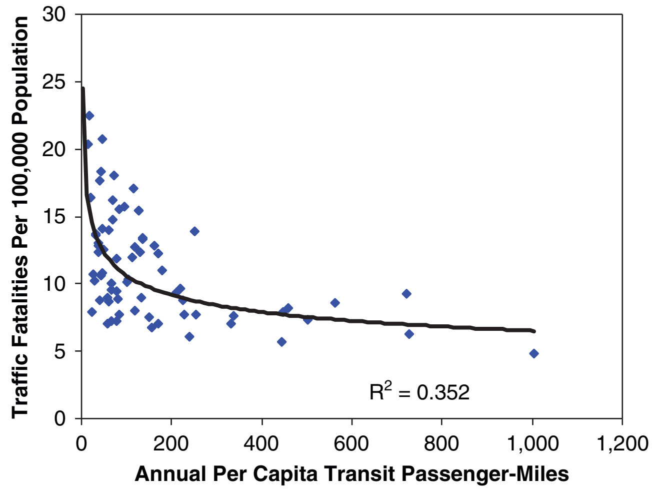

FIGURE 5 U.S. traffic deaths (each point = one U.S. urban area) (*6*).

Transit Fare Reductions

Description

Fares for public transport (including vanpools, buses, trains, and ferries) can be reduced in various ways, including public funding, targeted discounts, and commuter benefits (employers paying a portion of employee transit fares). Alternatively, transit service quality can be improved without increasing fares.

Travel Impacts

Reductions in fares for and service improvements in public transit tend to increase transit ridership. A 10% fare reduction typically increases transit ridership by 3% (*14*). A portion of this transit travel substitutes for automobile travel, particularly with higher-quality rapid transit services.

Safety Impacts

Public transport tends to have low crash and casualty rates per passenger mile, and overall traffic fatality rates (including automobile occupants, transit occupants and pedestrians) tend to decline in urban areas as transit ridership increases, as indicated in Figure 5. Lim et al. (*36*) describes how improvements in bus rapid transit in Seoul, South Korea, increased transit ridership by more than 20% while reducing total bus crashes by 26% and bus casualties by 11%.

Summary

Table 1 summarizes the travel and safety impacts of major categories of pricing reform.

Actual safety impacts depend on the amount and type of travel reduced. These reforms tend to be most effective and acceptable if implemented as an integrated program that includes improvements to alternative modes, encouragement programs, and smart growth development policies. Comparisons between otherwise similar geographic areas indicate that those areas with more efficient transport pricing (i.e., road, parking, and insurance prices that reflect marginal costs) have significantly less per capita vehicle travel and fewer per capita traffic casualties (typically 40% to 60%

TABLE 1 Transport Pricing Reform Impacts

Pricing Type	Description	Travel Impacts	Traffic Safety Impacts
Higher fuel prices	Increase fuel prices to finance roads and traffic services, and to internalize fuel economic and environmental costs.	European-level fuel prices reduce per capita vehicle travel 30%–50% compared with North America. Affects most vehicle travel.	Reducing vehicle travel provides about proportionate or greater crash reductions (i.e., a 30% mileage reduction provides at least 30% fatality reduction).
Road pricing	Tolls to reduce congestion and generate revenue.	Typically reduces affected vehicle travel 10%–30%. Usually applies to a small portion of total travel.	Can have significant safety benefits where applied, but total impacts are generally small.
Parking pricing	User fees to finance parking facilities. Can also include parking cash out and unbundling.	Typically reduces affected vehicle trips 10%–30%. Most common in city centers, campuses, and hospitals.	Because it is implemented most in congested urban areas, it probably provides relatively large crash reductions.
Distance-based pricing	Prorates vehicle insurance premiums and registration fees	Fully prorated pricing typically reduces affected vehicle travel 8%–12%, although most current examples have smaller price and travel impacts.	Potentially large safety benefits to affected vehicles. If widely applied, can provide large total safety benefits.
Public transport fare reductions	Reduce fares and commuter transit benefits to make public transit travel more attractive and affordable.	A 10% fare reduction typically increases ridership 3%, although only a portion of this substitutes for driving.	Fare reductions alone have modest impacts, but integrated programs can provide large safety benefits.

lower) than those where fuel, road, and parking are significantly underpriced (*37*).

CONSUMER IMPACTS

Pricing reforms are sometimes criticized as harmful to consumers, particularly those with lower incomes, but such criticism often reflects incomplete analysis. Although increased vehicle user fees may harm some motorists directly, the fees are often less harmful than alternative funding sources, and user charges help create more efficient and diverse transport systems, providing benefits to all travelers, including disadvantaged groups. For example, more efficient pricing can reduce congestion delays to bus riders and the delay and accident risk that vehicle traffic imposes on walkers and cyclists and, by increasing demand for alternative modes, can increase political and financial support to improve both walking and cycling conditions and public transport service.

Although user fees are regressive with respect to income (a dollar of taxes or tolls is a greater share of income for a lower-income than for a higher-income household), they are often less regressive than alternative funding options. Because lower-income residents on average own fewer vehicles, consume less fuel, drive their vehicles fewer annual miles, and use tolled highways less than average, they are generally in a better position with direct user fees and distance-based pricing than with indirect financing and fixed pricing. For example, Schweitzer and Taylor found that toll financing of expansion of urban highways is less regressive (it imposes less financial burden on lower-income households) than general tax financing (*38*). Charging motorists directly for the facilities and services allows consumers to save money if they reduce consumption, an opportunity that is unavailable with indirect financing. Because they tend to own fewer vehicles, drive less, and rely more on alternative commute modes, lower-income households are particularly likely to benefit from unbundled parking, distance-based vehicle fees, and parking cash out.

The impacts of pricing reform depend on the quality of transport and location options available to consumers. For example, if affordable housing is available only in automobile-dependent, urban-fringe locations, fuel tax increases and efficient road and parking pricing may impose significant financial burdens on lower-income commuters, but these burdens are reduced by improvements to alternative modes (walking and cycling facilities, ridesharing, the quality of public transit service, telework options) and increases to the supply of affordable housing in more accessible multimodal neighborhoods. Such policies tend to make pricing more effective at reducing vehicle travel and therefore more effective at reducing congestion, accidents, and pollution costs. As a result, many experts recommend to pricing reforms be implemented in conjunction with improvements to alternative modes and smart growth development policies (*39*).

CONCLUSIONS

A basic economic principle is that, as much as possible, prices should reflect total marginal costs of producing a good. This principle tends to be the most efficient and equitable. Transportation markets currently violate this principle: a major portion of costs are fixed or external and so do not reflect marginal costs. This situation increases transport problems, including traffic and parking congestion, facility costs, energy consumption, pollution emissions, patterns of inefficient land development, and accident risks.

Various pricing reforms (including higher fuel prices, efficient road and parking pricing, distance-based insurance and registration fees, and lower public transit fares) can help reduce these transport problems. Advocates generally promote individual reforms to achieve specific objectives, such as (*a*) road tolls to generate revenues and reduce congestion and (*b*) higher fuel taxes to generate revenue and encourage energy conservation. Traffic safety benefits are generally overlooked. Advocates of pricing reform seldom highlight safety benefits, and traffic safety experts seldom promote pricing reforms. Yet pricing reforms can provide significant safety benefits and, because they provide so many additional benefits, may often be the most cost-effective safety strategies overall, when all impacts are considered.

Fuel tax increases and distance-based pricing can probably provide the largest total safety benefits because they tend to affect the largest total amount of vehicle travel. Distance-based insurance can provide additional safety benefits because it gives higher-risk drivers an extra incentive to reduce mileage. Efficient road and parking pricing can provide significant safety benefits where they are applied. Reductions in fares for and service improvements in public transit provide smaller direct safety benefits but can have much larger impacts if they help create more transit-oriented communities where residents tend to own fewer cars and drive less than they would otherwise.

The much lower per capita traffic fatality rates in northern European countries and wealthy Asian countries can be largely explained by their relatively high transport prices, which reduce vehicle travel directly and help create more multimodal transport systems. Yet even these countries could implement additional pricing reforms, such as distance-based vehicle insurance and registration fees and more user-paid parking, to reduce their crash rates further.

Transport pricing reforms are particularly relevant for developing countries. Although per capita traffic fatality rates tend to decline as countries develop economically, the speed and amount of these declines can be affected by transport pricing and planning practices. Developing countries that apply efficient pricing and multimodal planning will likely achieve much lower (probably less than half) the per capita traffic fatality rates of countries that follow the North American model of low transport pricing and automobile-oriented planning.

Critics often claim that pricing reforms are regressive, but they are generally less regressive than are alternative transport facility financing options, and more efficient pricing can provide various benefits to physically, economically, and socially disadvantaged people by reducing traffic impacts on pedestrians and cyclists, offering new opportunities to save money when those people reduce vehicle ownership and use, and helping to build political and social support to develop more multimodal transport systems. Overall benefits, costs, and equity impacts depend on the quality of transport and land use options available, so it is generally best to implement pricing reforms as part of an integrated package that also includes improvements to alternative modes and land use development policies that help create more accessible, multimodal communities.

REFERENCES

1. Litman, T. *Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications.* Victoria Transport Policy Institute, Victoria, British Columbia, Canada, 2009. www.vtpi.org/tca. Accessed March 6, 2012.
2. *World Report on Road Traffic Injury Prevention: Special Report for World Health Day on Road Safety.* World Health Organization. www.who.int/violence_injury_prevention/publications/road_traffic/world_report/en/index.html. Accessed March 6, 2012.

3. *Desktop Reference for Crash Reduction Factors.* ITE, Washington, D.C., 2007.
4. *Transportation Planner's Safety Desk Reference.* FHWA, U.S. Department of Transportation, 2010.
5. Clarke, H., and D. Prentice. *A Conceptual Framework for the Reform of Taxes Related to Roads and Transport.* Prepared for Australian Treasury, Canberra, 2009.
6. Litman, T. *Pricing for Traffic Safety: How Efficient Transport Pricing Can Reduce Roadway Crash Risks.* Victoria Transport Policy Institute, Victoria, British Columbia, Canada, 2012. www.vtpi.org/price_safe.pdf. Accessed March 10, 2012.
7. Noland, R. B. Traffic Fatalities and Injuries: The Effects of Changes in Infrastructure and Other Trends. *Accident Analysis and Prevention,* Vol. 35, No. 4, 2003, pp. 599–611.
8. Edlin, A., and P. Karaca-Mandic. The Accident Externality from Driving. *Journal of Political Economy,* Vol. 114, No. 5, 2006, pp. 931–955.
9. Litman, T., and S. Fitzroy. *Safe Travels: Evaluating Mobility Management Traffic Safety Impacts.* Victoria Transport Policy Institute, Victoria, British Columbia, Canada, 2012.
10. Ferreira, J., and E. Minike. *A Risk Assessment of Pay-as-You-Drive Auto Insurance.* Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, 2010. www.clf.org/wp-content/uploads/2010/12/CLF-PAYD-Study_November-2010.pdf. Accessed March 6, 2012.
11. Sivak, M., and B. Schoettle. *Toward Understanding the Recent Large Reductions in U.S. Road Fatalities.* University of Michigan Transportation Research Institute, Ann Arbor, 2010. http://deepblue.lib.umich.edu/bitstream/2027.42/71390/1/102304.pdf. Accessed March 6, 2012.
12. Vickrey, W. Automobile Accidents, Tort Law, Externalities, and Insurance: An Economist's Critique. *Law and Contemporary Problems,* Vol. 33, 1968, pp. 464–487. www.vtpi.org/vic_acc.pdf. Accessed March 6, 2012.
13. Goodwin, P., J. Dargay, and M. Hanly. Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. *Transport Reviews,* Vol. 24, No. 3, May 2004, pp. 275–292.
14. Litman, T. *Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior.* Victoria Transport Policy Institute, Victoria, British Columbia, Canada, 2010.
15. Small, K. A., and K. Van Dender. Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect. *Energy Journal,* Vol. 28, No. 1, 2007, pp. 25–51.
16. Gillingham, K. *Identifying the Elasticity of Driving: Evidence from a Gasoline Price Shock in California.* U.S. Association for Energy Economics, 2010. www.iaee.org/en/students/best_papers/Gillingham.pdf. Accessed March 6, 2012.
17. Litman, T. *Changing Vehicle Travel Price Sensitivities: The Rebounding Rebound Effect.* Victoria Transportation Policy Institute, Victoria, British Columbia, Canada, July 26, 2012. www.vtpi.org/VMT_Elasticities.pdf. Accessed March 6, 2012.
18. Ebert, S., G. P. Metschies, D. Schmid, and A. Wagner. *International Fuel Prices,* 6th ed. German Agency for Technical Cooperation, Eschborn, Germany, Dec. 2009. www.gtz.de/en/themen/29957.htm.
19. Wachs, M. A Dozen Reasons for Raising Gasoline Taxes. *Public Works Management and Policy,* Vol. 7, 2003, pp. 235–242.
20. Sivak, M. Mechanisms Involved in the Recent Large Reductions in U.S. Road Fatalities. *Injury Prevention,* Vol. 15, No. 3, 2009, pp. 205–206.
21. Grabowski, D. C., and M. A. Morrisey. Gasoline Prices and Motor Vehicle Fatalities. *Journal of Policy Analysis and Management,* Vol. 23, No. 3, 2004, pp. 575–593.
22. Grabowski, D. C., and M. A. Morrisey. Do Higher Gasoline Taxes Save Lives? *Economics Letters,* Vol. 90, 2006, pp. 51–55.
23. Leigh, J. P., and E. M. Geraghty. High Gasoline Prices and Mortality from Motor Vehicle Crashes and Air Pollution. *Journal of Occupational and Environmental Medicine,* Vol. 50, No. 3, March 2008, pp. 249–254.
24. Chi, G., A. G. Cosby, M. A. Quddus, P. A. Gilbert, and D. Levinson. Gasoline Prices and Traffic Safety in Mississippi. *Journal of Safety Research,* Vol. 41, No. 6, 2010, pp. 493–500.
25. Chi, G., M. A. Quddus, A. Huang, and D. Levinson. Gasoline Prices Effects on Traffic Safety in Urban and Rural Areas: Evidence from Minnesota, 1998–2007. Working paper. http://nexus.umn.edu/Papers/GasolinePricesAndTrafficSafetyMinnesota.pdf.
26. Chi, G., J. R. Porter, A. G. Cosby, and D. Levinson. The Impact of Gasoline Price Changes on Traffic Safety: A Time Geography Explanation. *Journal of Transport Geography* (forthcoming).
27. Chi, G., X. Zhou, T. E. McClure, P. A. Gilbert, A. G. Cosby, L. Zhang, A. A. Robertson, and D. Levinson. Gasoline Prices and Their Relationship to Drunk-Driving Crashes. *Accident Analysis and Prevention,* Vol. 43, No. 1, 2011, pp. 194–203.
28. *Fuel Economy Standards Versus a Gasoline Tax.* Congressional Budget Office, 2003.
29. Wenzel, T., and M. Ross. *Increasing the Fuel Economy and Safety of New Light-Duty Vehicles.* Lawrence Berkeley National Laboratory, Berkeley, Calif., 2006.
30. *Central London Congestion Charging: Impacts Monitoring, Fourth Annual Report.* Transport for London, June 2006.
31. Lovegrove, G. R., and T. A. Litman. Macrolevel Collision Prediction Models to Evaluate Road Safety Effects of Mobility Management Strategies: New Empirical Tools to Promote Sustainable Development. Presented at 87th Annual Meeting of the Transportation Research Board, Washington, D.C., 2008.
32. Lovegrove, G., C. Lim, and T. Sayed. Community-Based, Macrolevel Collision Prediction Model Use with a Regional Transportation Plan. *ASCE Journal of Transportation Engineering,* Vol. 136, No. 2, Feb. 2010, pp. 120–128.
33. Shoup, D. *The High Cost of Free Parking.* Planners Press, Chicago, 2005.
34. Spears, S., M. G. Boarnet, and S. Handy. *Draft Policy Brief on the Impacts of Parking Pricing Based on a Review of the Empirical Literature.* California Air Resources Board, Sacramento, 2010.
35. Litman, T. Distance-Based Vehicle Insurance as a TDM Strategy. *Transportation Quarterly,* Vol. 51, No. 3, Summer 1997, pp. 119–138.
36. Lim, S., W. Kim, S. Jung, and M. Chang. Bus Traffic Accident Analysis: Before and after Transportation Reform in Seoul. *Seoul Studies,* June 2006.
37. Buehler, R. Transport Policies, Automobile Use, and Sustainable Transport: A Comparison of Germany and the United States. *Journal of Planning Education and Research,* Vol. 30, No. 1, 2010, pp. 76–93.
38. Schweitzer, L., and B. Taylor. Just Pricing: The Distributional Effects of Congestion Pricing and Sales Taxes. *Transportation,* Vol. 35, No. 6, 2008, pp. 797–812.
39. *Special Report 303: Equity of Evolving Transportation Finance Mechanisms.* Transportation Research Board of the National Academies, Washington, D.C., 2011.

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