SPECIAL
REPORT
285

The Fuel Tax

AND ALTERNATIVES FOR TRANSPORTATION FUNDING

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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AND ALTERNATIVES FOR TRANSPORTATION FUNDING

Committee for the Study of the Long-Term Viability of
Fuel Taxes for Transportation Finance

TRANSPORTATION RESEARCH BOARD
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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

The Transportation Research Board (TRB) formed the Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance to respond to concerns that present funding arrangements, especially fuel taxes, may become less reliable revenue sources for transportation programs in the future. At the same time, transportation agencies are interested in developments in toll collection technology and in public–private road projects that suggest opportunities to try fundamentally new approaches to paying for transportation facilities. The goals of the study were to assess what recent trends imply for the future of traditional transportation finance, identify finance alternatives and the criteria by which they should be evaluated, and suggest ways in which barriers to acceptance of new approaches might be overcome. The study was sponsored by the state transportation departments through the National Cooperative Highway Research Program, the Federal Highway Administration, and TRB.

The committee's conclusions address the viability of present revenue sources, the merits of present transportation finance arrangements, and the potential value of various reform options. The recommendations propose immediate changes to strengthen the existing highway and transit finance system and actions to prepare the way for more fundamental reform in the long term. Because the impetus for the study was concern for the continued reliability of the revenues derived from the special fees and taxes paid by highway users, most of this report is devoted to questions about future tax revenue, alternative forms of highway user charges, how these charges affect highway system performance, and related aspects of highway finance. Problems relating to finance of public transit were not considered as comprehensively. An important feature of present transportation finance arrangements is the dedication of portions of highway user revenues to transit. The committee considered transit funding primarily insofar as it is linked in this way to highway user fee revenue.

The committee received briefings at its meetings from federal, state, and local government transportation administrators and from experts in various aspects of transportation finance. The committee thanks Tyler Duvall, Patrick

DeCorla-Souza, Michael Freitas, and James March of the U.S. Department of Transportation; Elizabeth Paris of the staff of the U.S. Senate Finance Committee; Charles Stoll of the California Department of Transportation; James Whitty of the Oregon Department of Transportation; Ellen Burton of the Orange County Transportation Authority; Brian Mayhew of the Metropolitan Transportation Commission; Marlon Boarnet of the University of California at Irvine; Helen Sramek of AAA; Darrin Roth of the American Trucking Associations; Greg Hulsizer of California Transportation Ventures, Inc.; Arlee Reno and Gary Maring of Cambridge Systematics; Dawn Levy of Cassidy & Associates; Arthur Guzzetti of the American Public Transportation Association; Jeffrey Parker; Alan Pisarski; and Arthur Bauer. The committee also thanks Paul Sorensen and Brian Taylor of the University of California at Los Angeles, authors of a resource paper prepared for the committee on road use metering systems. The executive summary of that paper is included as Appendix C of this report. The contents of the resource paper are the responsibility of the authors.

The report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that assist the authors and NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The committee thanks the following individuals for their participation in the review of this report: David L. Greene, Oak Ridge National Laboratory, Knoxville, Tennessee; Karen J. Hedlund, Nossaman, Guthner, Knox, & Elliott LLP, Arlington, Virginia; Herbert S. Levinson, Herbert S. Levinson Transportation Consultant, New Haven, Connecticut; David Luberoff, Harvard University, Cambridge, Massachusetts; Jeff Morales, Parsons Brinckerhoff Quade and Douglas, Inc., Sacramento, California; Ian W. H. Parry, Resources for the Future, Washington, D.C.; Arlee T. Reno, Cambridge Systematics, Inc., Chevy Chase, Maryland; and Paul P. Skoutelas, PB Consult, Inc., Pittsburgh, Pennsylvania.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the committee's conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by John S. Chipman, University of Minnesota, and C. Michael Walton, University of Texas at Austin. Appointed by NRC, they were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Joseph R. Morris managed the study and drafted the final report under the guidance of the committee and the supervision of Stephen R. Godwin, Director of Studies and Information Services. Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. Special appreciation is expressed to Norman Solomon, who edited the report; Jennifer Weeks, who prepared the prepublication copy; and Juanita Green, who managed the book design and production, all under the supervision of Javy Awan, Director of Publications. Frances Holland assisted with meeting arrangements and communications with committee members.

Contents

Summary

Highway[1] programs derive most of their funding from user fees, which are special taxes and charges incurred by vehicle operators in relation to their use of roads. Governments dedicate most highway user fee revenue to highway spending ($85 billion out of $107 billion collected in 2004) and also devote a share to transit ($11 billion in 2004). Fuel taxes generate most highway user fee revenue (64 percent of the total in 2004); other user fee revenues are from vehicle registration fees, excise taxes on truck sales, and tolls.

This study assesses the revenue-generating prospects of fuel taxes and other user fees and identifies alternatives to the present finance arrangement. Transportation officials have been concerned that the sources that provided stable and growing revenue for their programs for many decades could become unreliable in the future. They see two possible threats to the viability of the established arrangement: that fuel consumption and fuel tax revenue could be depressed by changes in automotive technology, rising fuel prices, or new energy or environmental regulations; and that the user fee finance principle that has been the basis of highway finance may be eroding in practice, as nonhighway applications of user fee revenues proliferate and dependence on revenue from sources other than user fees grows. The vulnerability of excise tax revenue to inflation in an era when tax rate increases often seem politically infeasible magnifies these concerns.

In judging the merits of the present finance system and alternatives, the Transportation Research Board study committee focused on how finance arrangements affect the performance of the transportation system by influencing the decisions of travelers and government investment and management decisions. This

[1] In this report, the term "highway" refers to all public highways, roads, and streets, and "transit" refers to all public local bus, subway, commuter rail, and trolley services, unless otherwise qualified. Intercity public transportation is excluded from the definition of transit.

criterion led the committee to give special attention to methods of charging fees that could be directly related to the cost of providing services—in particular, tolls and mileage charges.

The committee did not estimate how much governments should spend on transportation and did not interpret its task as devising revenue mechanisms to support an increased level of spending. There is no certainty that finance reform in the direction of improving the efficiency of transportation would increase revenues. A reformed finance system would remain subject to many of the external political and economic constraints that limit the revenue potential of the present system. However, reform would help transportation agencies to manage capacity and to target investment to projects with the greatest benefit to the public. Each dollar spent would be more effective and services would improve, and it is conceivable that the public would be willing to pay more for transportation programs that worked better.

CONCLUSIONS

The committee's conclusions concern the two parts of its charge: to assess threats to the viability of the present finance system and to identify directions for reform of transportation finance.

Viability of Revenue Sources

The risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years; that is, it should be able to fund growth in capacity and some service improvements, although not at a rate that will reduce overall congestion.

Threat of Loss of the Tax Base

A reduction of 20 percent in average fuel consumption per vehicle mile is possible by 2025 if fuel economy improvement is driven by regulation or sustained fuel price increases. Offsetting the revenue effect of such a gain would not require unprecedented increases in fuel tax rates. The willingness of legislatures to enact increases may be in question, but the existing revenue sources will retain the capacity to fund transportation programs at historical levels.

Without new regulations, fuel price increases alone probably will stimulate only a small improvement in fuel economy in this period.

Three factors will constrain the rate of progress on fuel economy: first, consumers prefer to maintain or enhance the performance and size of the vehicles they buy; second, new vehicles that offer performance and cost close to those of

today's vehicles with significantly lower fuel consumption will require time to be brought into large-scale production; and finally, the stock of vehicles on the road turns over slowly. Energy forecasts are speculative; however, there are grounds for expecting that, although the relatively high prices of 2004–2005 may persist, output will increase sufficiently to moderate the long-term price trend. Supplies are available from multiple sources that can be developed and brought to market at lower cost than the 2005 price, and maintaining the price of oil at too high a level is not in the long-term interest of the major producers because it encourages conservation and stimulates development of alternative sources.

Erosion of Established Finance Practices

Government transportation finance practices have been remarkably stable and resilient since the creation of the present federal highway program in 1956. However, some potential sources of stress are evident, particularly in certain states where the local share of responsibility is high. These include pressures to expand use of highway user fee revenue for nonhighway purposes, the growth of transit spending as a share of local transportation spending, and the vulnerability of revenues to acceleration of inflation.

Merits of the Present System

The finance system has contributed to the success of the highway program in delivering a positive return on the national investment in highways because fees modestly discourage motorists from making trips of little value, spending is limited by the revenues generated from users, and motorists can see the cost of providing roads in the fuel taxes and registration fees they pay. However, highway programs have important failings related to finance. The system does not provide a strong check that individual projects are economically justified. Congestion and pavement costs are tolerated that could be avoided if motorists were charged prices that more closely matched the cost of their use of roads.

Directions for Reform

Although the present highway finance system can remain viable for some time, travelers and the public would benefit greatly from a transition to a fee structure that more directly charged vehicle operators for their actual use of roads. The growing cost of maintaining acceptable service under present funding and pricing practices may at some point compel reforms that would increase efficiency. The transition could proceed in stages, starting with closer matching of present fees to costs and expanded use of tolling. Ultimately, in the fee system that would provide the greatest public benefit, charges would depend on mileage, road and

vehicle characteristics, and traffic conditions, and they would be set to reflect the cost of each trip to the highway agency and the public.

The potential benefits of a transition to direct charging are improved operation of the road system and better targeting of investment to the most valuable projects. Revenues from charges set to reflect the cost of providing service would provide an accurate indication of where capacity expansions would have benefit. Governments that own and operate roads could control fees and funding, so dependence on intergovernmental aid would be reduced. Reform in this direction offers the best opportunity for increasing the cost-effectiveness of spending and mitigating congestion.

The committee identified two complementary tracks for practical reform:

- *Toll roads and toll lanes:* An important opportunity exists today to create an extensive system of tolled expressways and expressway lanes employing existing electronic toll collection technology and variable pricing. Although such a toll program probably would not greatly increase the funds available for highways, it could expedite construction of critical highway improvements, provide a tool for managing congestion, and help gain public acceptance of road pricing.
- *Road use metering and mileage charging:* This appears to be the most promising technique for directly assessing road users for the costs of individual trips within a comprehensive fee scheme that will generate revenue to cover the costs of highway programs. It uses communications and information technology to assess charges according to miles traveled, roads used, and other conditions related to the cost of service. Unlike conventional tolling, which is applicable only on expressways, road use metering could be used to manage and provide funding for all roads. Conversion to road use metering will require a sustained national effort. Governments must decide on the goals of the effort, authorities for setting fees and controlling revenue, the basis for determining fees, and how best to involve the private sector. Resolution of privacy and fairness concerns will be a prerequisite.

As the finance system evolves, governments can keep it on a course leading to the necessary improvements by adhering to the following rules:

- Maintain the practice of user fee finance, a system in which users of facilities are charged fees or special taxes, rates reflect the costs to serve each user, and expenditures equal the fee revenue.
- Seek opportunities where possible to apply pricing—that is, allow fees to ration access to facilities.
- Align responsibilities so that local governments provide facilities that serve mainly local travel, states serve regional traffic, and the federal government

retains only functions that it can perform more effectively than state and local governments. Governments must control the resources required to carry out these functions; therefore a goal of reform should be to allow each jurisdiction to collect fees from all users of its facilities.

- Give full consideration to the environmental and equity consequences of reform. Fundamental finance reform that aligned fees more closely with costs would eventually have profound effects on the locations of households and industries. The overall economic and environmental impacts of reform would be positive, but some individuals and communities would suffer harm if no provisions were made for compensation.

RECOMMENDATIONS

The committee proposes immediate changes to strengthen the existing highway and transit finance system and actions to prepare the way for fundamental reform.

1. Maintain and Reinforce the Existing User Fee Finance System

Because superior alternatives will require time to develop, the nation must continue to rely on the present framework of transportation funding for at least the next decade. Therefore, governments must take every opportunity to reinforce the proven features of the present system, in particular, user fee finance in the highway program. The following actions would help to maintain the effectiveness of the overall system:

- The federal government and the states should make adjustments to user fee rates (for example, adjustments in registration and permit fees to better align payments with cost responsibilities) that would provide incentives for more cost-conscious use of highways by operators of large trucks and other vehicles.
- Congress and the states should consider eliminating fuel tax exemptions that are commonly abused and take other measures to reduce losses to tax evasion.
- The states should make provision for advanced-technology vehicles in the user fee structure so that operators of these vehicles contribute to the upkeep of highways on a basis similar to that of other users. In particular, future vehicles that consume fuels not currently taxed should contribute on some basis, and incentives to promote conservation technologies should be designed so that they reasonably apportion the cost burden of the promotion among road users and the public and do not encourage inefficient use of roads.

- Regardless of the overall scope of the federal surface transportation program in the future, the federal government should retain certain core responsibilities, including aid to ensure that the states to not underinvest in routes of national significance, the setting of standards, environmental regulation and enforcement, and research and development.

2. Expand Use of Tolls and Test Road Use Metering

The Federal Role in Promoting Toll Road Development

The federal government should encourage states to experiment with arrangements for tolling and private-sector participation in road development. To this end, states should be allowed to impose tolls on existing roads that were built with federal aid, and they should be allowed flexibility in the design of toll systems.

Road Use Metering and Mileage Charging

The states and the federal government should undertake serious exploration of the potential of road use metering and mileage charging. Creation of a structure to support individual states that decide to conduct trials or pilot implementations may be the most practical initial arrangement. However, a program with national focus will be required, with federal leadership and funding aid for research and testing.

The first requirement will be technical trials to evaluate the reliability, flexibility, cost, security, and enforceability of alternative designs and to gain information on proper administration of these systems and user acceptance. Once technically proven designs are available, the federal government should support one or more trial implementations that would be on a large scale and fully functional but that would be limited in scope with respect to the region, roads, or vehicles involved. The participating states would require federal technical coordination and financial aid. Evaluation must be integral to the design of trials and must be provided for in schedules and budgets. Designs and pilot implementations should be compatible with the principle that each state and local jurisdiction should control charges on and revenues generated by the roads it owns.

3. Provide Stable, Broad-Based Tax Support for Transit

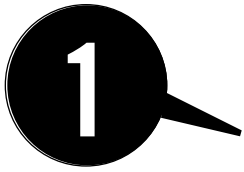
Reforms of highway finance arrangements in the future will give rise to needs for reviewing and adjusting the relationship of highway and transit funding. The following are guidelines that should be considered:

- Transit systems at present require dedicated, broad-based tax support. Developing such support will be necessary in order to maintain and expand transit services.

- Greatly increasing transfers of highway user fee revenues to fund expanded transit services would risk a loss of travel benefits through declining highway performance that could be greater than the transit benefits gained. This risk imposes a limit on the potential of existing highway user fees as a source of transit funding.
- Federal and state transportation aid should be provided for the purpose of relieving local governments of the burden of serving nonlocal needs rather than subsidizing local services.
- Road pricing instituted in metropolitan areas should be used to increase transit's financial self-sufficiency by eliminating subsidies to highway travel, giving transit the market power to increase fare revenue, and improving bus service quality.

4. Evaluate the Impact of Finance Arrangements on Transportation System Performance

Transportation agencies must develop new capabilities for research, evaluation, and communication with the public in order to manage finance reform successfully over the next few decades. If tolls and mileage charges become important sources of highway funding, agencies will be faced with fundamentally new kinds of management decisions and information requirements. At the same time, the effects of the new charges will provide information never before available about the value of highway facilities. To develop the capability to fulfill the new management and information requirements, an organized program will be necessary. The institutional structure of the program must provide for a joint federal–state effort, guarantee that scientific evaluations of alternatives are carried out, and build public confidence through open processes.



Introduction

Like all government agencies in the United States, those charged with providing highways and public transit[1] are perennially faced with the challenge of serving growing needs with constrained resources. The past decade has been particularly challenging as transportation agencies coped first with rapid traffic growth during the economic boom of the 1990s and then with stagnant revenues and state government fiscal crises in the aftermath of the 2001 recession. The federal surface transportation aid program was debated for 2 years after its expiration in 2003 before reauthorization in 2005, as proposals to increase spending clashed with opposition to any increase in highway user tax rates to fund the expansion.

Recent circumstances have heightened long-standing worries of transportation officials that funding sources, particularly fuel taxes, that provided stable and growing revenue for transportation programs for 40 years are going to become unreliable in the future. If petroleum price increases or government interventions to reduce pollutant emissions or petroleum consumption lead to widespread use of more efficient automobile engines or lighter passenger vehicles, maintaining revenue will require that legislatures accelerate rate increases. In addition, there is concern that the political consensus supporting transportation taxes may be eroding as the goals of the programs become more diffuse, the public becomes more sensitive to environmental and land use impacts of expanding infrastructure, and increasing population density and wealth drive up the costs of infrastructure expansion. The payers of transportation fees and taxes may view the deterioration of performance as evidence that transportation agen-

[1] In this report, the term "highway" refers to all public highways, roads, and streets, and "transit" refers to all public local bus, subway, commuter rail, and trolley services, unless otherwise qualified. Intercity public transportation is excluded from the definition of transit.

cies are not delivering their money's worth rather than as evidence that rate increases are called for.

Opportunities are at hand for fundamentally new approaches that could provide a sound basis for transportation finance and at the same time improve the efficiency and quality of transportation services. Progress in the technologies of toll collection and road use metering has greatly diminished the obstacles of cost and inconvenience that have discouraged imposition of direct charges on the users of most roads in the past. With the application of these technologies, highway services could be paid for by metering each customer's use and charging accordingly, just as utilities such as water and electricity are paid for today. Development of this revenue source would maintain the established practice of funding highways largely through fees paid by users, allow fees to be much more closely tied to the cost of providing service for each user, and provide information to transportation agencies about which investments in capacity would yield the greatest benefits. Eliminating the connection between highway user revenues and motor vehicle fuel economy would avoid the potential conflict between transportation funding objectives and policies intended to promote energy conservation or emissions reductions. In addition, facilities that generated their own revenue would be suited to operation by private-sector franchisees, so there would be opportunities to supplement public efforts with private capital and skills to carry out infrastructure projects.

Initial steps toward these new kinds of transportation finance arrangements are taking place today. Toll roads featuring automatic toll collection and charges that can be varied to optimize traffic flow, systems to meter vehicle use over an extensive network of roads and assess charges proportional to mileage, and roads developed and operated by private firms receiving revenue from road user fees are in operation in the United States or in other countries. However, before these arrangements can become major components of the transportation finance system, their effectiveness must be demonstrated to the public's satisfaction and the institutional capabilities needed to manage them on a large scale must be developed. In the meantime, it will be worthwhile to seek refinements that could improve the system's capacity to provide the right level of funding and direct funds to the best uses within the established structure of fees, revenue sources, and assignment of responsibilities among governments.

The Transportation Research Board (TRB) convened the Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance to assess what recent trends imply for the future of traditional transportation finance, identify finance alternatives and the criteria by which they should be evaluated, and suggest ways in which barriers to acceptance of new approaches might be overcome. The study was sponsored by the state transportation departments through the National Cooperative Highway Research Program, the Federal Highway Administration, and TRB. This chapter describes the transportation finance prob-

lems that are the motivation of the study—in particular, as they are seen by state governments, which are responsible for collecting most highway user taxes and fees and for most highway spending—and explains the charge to the study committee. The final section of the chapter identifies guidelines that the committee applied in its evaluation of alternative government policies for financing transportation.

STUDY ORIGIN: TRANSPORTATION FINANCE PROBLEMS

Several states have undertaken high-level reviews of transportation finance and tax issues in recent years (Reno and Stowers 1995, Appendix B; CTI 1996; CRC 1996; CRC 1997; CRC 1998; Road User Fee Task Force 2003). These reports provide examples of the states' diagnoses of their finance problems. A Commission on Transportation Investment was formed in 1995 by the state of California "to investigate California's investment in transportation infrastructure" (CTI 1996, 5). The commission's report defines the finance problem facing the state's transportation program as follows:

> California's transportation system has been funded from a dedicated gasoline tax since 1923. . . . Over the last 20 years, however, several trends have occurred which have led some to question the State's current reliance on this revenue source.
>
> One of these trends is the increasing fuel economy of today's vehicles. . . . This creates the ironic situation of total usage of the system increasing while the amount of revenue is not increasing at a commensurate rate.
>
> The second trend . . . is the development of alternative fuel vehicles. These fuels . . . are subject to tax rates that . . . are 12 to 58 percent less than the equivalent tax rate for gasoline. . . . Fuel taxes were originally conceived as a direct user fee—the more one drives, the more one pays. As alternatives and more efficient fuels and vehicles come into use, the linkage between the gas tax and the use of transportation facilities weakens. . . . This result can be credited to explicit public policies stemming from national energy crises and desires to reduce air pollution. . . . California motorists pay fuel taxes with the assumption that these revenues are used to maintain and expand the transportation system. But successful implementation of the policies noted above [is] causing the fuel tax to be an unreliable source for all of the system's needs. (CTI 1996, 13–14)

The commission also cites "a legislative and political climate hostile to new taxes" as a financial reality (CTI 1996, 25). The report offers a range of options for coping with the problems, from immediate to long term and from modest to radical (CTI 1996, 26–28):

1. Living within our means.
2. Increasing the fuel tax. . . . The disadvantages are that there is little political support to raise taxes, the fuel tax is not responsive to the increasing fuel efficiency

of vehicles, and it does not capture the increasing use that non-gasoline powered vehicles are likely to be making of the state's roads.
3. Require alternative fuels . . . to pay taxes that are equivalent on a per mile traveled basis to the current gasoline and diesel fuel tax.
4. Vehicle Miles Traveled . . . Fee [i.e., a fee proportional to miles traveled].
5. Direct Road Pricing [i.e., a fee depending not only on miles traveled but also on the road used and traffic conditions].

Immediate actions recommended include curtailing applications of highway user revenues to nontransportation purposes, expanding opportunities for public–private partnerships, and introduction of high-occupancy/toll lanes. This list of immediate and long-term options is representative of current proposals for resolving state highway program funding problems.

Oregon's Road User Fee Task Force was formed by the legislature in 2001 with a specific practical charge: "to develop a design for revenue collection for Oregon's roads and highways that will replace the current system for revenue collection" (Road User Fee Task Force 2003, 1). The task force defines the state highway finance problem in nearly the same terms as California's Commission on Transportation Investment (Road User Fee Task Force 2001, 1):

> Fuel tax revenue constitutes the bulk of the total funding available for Oregon roads. . . . New technology will soon greatly improve the average fuel efficiency of the statewide passenger vehicle fleet. . . . As a result of fuel efficiency improvements, Oregon fuel tax revenues from the sale of gasoline are likely to level off during the next 10 years and then drop permanently.

The task force's proposal has three provisions (Road User Fee Task Force 2003, 25): imposition of new charges in place of existing ones, including a mileage fee, congestion pricing (i.e., a charge for road travel that is higher at times and locations where congestion is high), and tolling of all newly constructed roads, bridges, or lanes; a 20-year phase-in period during which the state would operate both the mileage fee and the fuel tax; and pilot testing of hardware and administrative arrangements for the mileage fee as the first step toward implementation. This proposal is described in more detail in Chapter 5.

With similar motivations, 15 states from all regions of the country pooled funds to conduct the 2002 study *A New Approach to Road User Charges.* The study's report cites, in addition to the concern for revenue adequacy emphasized by the Oregon and California panels, other shortcomings of the present fuel tax system, especially "a weak relationship to the relative costs of particular trips such that some vehicle operators pay user charges that exceed the costs they impose, while others pay substantially less than their costs." Thus, "vehicle operators are not given signals to make them aware of the costs a particular trip may impose on society" (Forkenbrock and Kuhl 2002, 1). The report proposes

technical and administrative arrangements of a system for metering and charging for each vehicle's road use and recommends a field test. This proposal also will be described in Chapter 5.

A final example, the report on highway finance of the nongovernmental Citizens Research Council of Michigan, was issued at a time when Michigan was ranked low among the states in fuel tax rates and road conditions and a debate on raising tax rates was under way. The state increased its gasoline tax rate from 15 to 19 cents per gallon the following year. The theme of the report was that increasing revenue would by itself be an inadequate response to the fiscal problem. The main proposals were the following (CRC 1996, 4–13): user tax increases must be accompanied by management reforms in the highway program ("unless the system is restructured both financially and administratively, it is very likely that any additional dollars will not purchase the improvement in transportation services that might be expected"); jurisdictional control of roads should be updated, with the state taking over responsibility for roads in local hands that serve mainly through traffic; an increase in truck registration fees should be considered; methods of determining priorities must be improved; contracting out should be increased; and indexation of the fuel tax rate to compensate for inflation should be considered.

Three distinct justifications for considering an overhaul of transportation finance and highway user fees emerge from these state analyses: a potentially diminishing tax base, erosion of the user fee finance principle, and the opportunity to improve efficiency. In summary, proponents of changing transportation funding arrangements have claimed that developments in motor vehicle technology will threaten the revenue capacity of existing fees, that the finance system has diverged from its founding principles with harmful consequences, and that reform in the direction of pricing would increase the public benefits of government transportation expenditures. The study committee examined the evidence supporting each claim.

Potentially Diminishing Tax Base

Among the foremost state concerns in the reports is that energy supply, environmental constraints, or changes in automotive technology will reduce fuel consumption, with reduced revenues as the consequence. The implicit assumption behind this fear is that fuel tax rates will not be raised to compensate. Yet if the transition to alternative energy sources is gradual, it is not self-evident that the tasks of adjusting rates and incorporating new fuels into the tax base as the need arises will necessarily entail such a threat to fiscal soundness. The California report cites rising political resistance to tax rate increases; however, as Chapter 2 will describe, nationwide average constant-dollar user fee revenue per vehicle mile has held fairly constant for the past 25 years. The fear that new revenues

will not come online as needed may arise from three considerations. First, subsidies in the form of waivers of excises have been a popular way to promote alternative energy development (e.g., the fuel tax subsidy granted to gasohol). Second, imposing new kinds of fees presents technical and administrative problems. Third, state officials recall the period from the mid-1970s to the early 1980s when the combination of high inflation, slow economic growth, and increasing automotive fuel economy reduced constant-dollar highway user fee revenue by 50 percent. Tax rates were eventually adjusted, but only after a lag of nearly a decade.

Erosion of the User Fee Finance Principle

One characterization of the finance scheme of the federal-aid highway program (whose centerpiece is a trust fund receiving revenues from user fees), and of the similar highway finance schemes of many states, is that of a compact between highway users and the government highway agency. Users agree to pay fees with the understanding that the agency will spend the revenue to provide highway services. At the creation of the Federal Highway Trust Fund in 1956, all revenue from a specified collection of excise taxes on fuels, vehicles, and parts was dedicated to the fund, to be distributed to the states for highway uses. Over time, the revenue from these taxes has accumulated additional functions, especially at the federal level. Since 1979, gasohol (a blend of gasoline with ethanol produced from grain) has received preferential tax treatment to promote alternative fuels and aid farmers (the revenue loss, after a 2004 change in federal law, is now borne by the general fund rather than by transportation programs alone); since 1983, a portion of the fuel tax is dedicated to a fund for mass transit capital projects; since 1987, a small portion of the fuel tax has been dedicated to the Leaking Underground Storage Tank Trust Fund; and from 1990 to 1997 a significant portion of the fuel tax was deposited in the general fund for deficit reduction (and the general fund continued to receive minor amounts until 2005). During the fiscal crises that many states faced in the early 2000s, a number of legislatures chose to apply user fee revenues normally devoted to transportation to general purposes instead (e.g., AAA Mid-Atlantic 2005). Other uses of the revenues are sometimes proposed. Meanwhile, at the state and local levels, it has become increasingly common to dedicate revenues from particular taxes other than gasoline or motor vehicle excises (for example, sales taxes) as revenue sources for transportation. (When the law that establishes a tax specifies that revenue from the tax is to be used for certain specified purposes, the tax is called a dedicated tax.)

The accretion of applications of highway user fee revenue to nonhighway purposes, together with the popularity of dedicated revenue sources that cannot be regarded as user fees, weakens the principle of linkage between the fees paid and the cost of maintaining the highways, which has been the traditional political rationale for the present finance scheme. Of course, there are legitimate

grounds for arguing that transit and the other uses to which user fee revenues have been dedicated are as reasonable uses of the revenue as is highway construction, and there has always been controversy over the merits of the user fee–trust fund arrangement in highway finance. However, if the present system on the whole tends to promote public welfare, then the states are justified in searching for ways to reinforce its core principles.

Opportunity to Improve Efficiency

In political discussions, the transportation finance problem traditionally has been defined as primarily a problem of revenue adequacy: how to raise revenues sufficient to maintain a desired level of spending or serve defined transportation needs in a manner that is perceived as fair by the public and highway users. This definition of the problem is incomplete because it does not take into account the connection between finance arrangements and the performance of the highway system. Finance provisions affect the quality of investment decisions and the efficiency of operations. Growing congestion and breakthroughs in technology for metering road use, as well as interest in exploiting new revenue sources, have spurred public agencies to consider the use of pricing to manage congestion. It appears to be less widely appreciated that finance reform, especially reform in the direction of pricing, would exert a powerful influence on project selection and overall spending levels, with the potential for improving the targeting of investment spending to the highest-payoff projects and helping the states to determine the optimum level of highway spending. Reforms that reduced arbitrary variation in tax and fee payments among highway users would make the finance system more fair as well.

CHARGE TO THE COMMITTEE

These motivations for undertaking reform are reflected in TRB's charge to the committee (defined in the task statement in Box 1-1). The committee was asked to judge the significance of the two hypothesized threats to the viability of revenue sources and finance arrangements. The first is that rising fuel prices, new automotive technology, or new environmental and energy regulations will affect revenues in the next few decades and that the financial side effects of these forces, in the absence of reform, will cause a decline in the performance of the highway system. The second is that trends in the political choices being made about transportation funding at the federal, state, and local levels today threaten the viability of finance arrangements and the performance of the transportation system. Finally, the committee was asked to identify finance alternatives that would improve the services that transportation programs afford the public. As the term

BOX 1-1

Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance: Statement of Task

The study will examine current practices and trends in finance of roads and public transit and evaluate options for a long-term transition to alternative finance arrangements from the present system, which relies heavily on fuel taxes whose revenues are dedicated to transportation spending. The goals of the study are to

- Assess the future revenue-generating prospects of the present user fee tax base, especially the gas tax, considering developments in fuel prices, automotive technology, and environmental and energy regulation, and the likely time frame for future technology transitions in transportation.
- Examine developments in transportation finance policies of federal, state, and local governments.
- Assess the implications of finance trends for the performance of the transportation system, and whether benefits could be attained through reform.
- Identify alternatives to the present finance scheme and the criteria by which they should be judged, considering the influence of finance arrangements on the performance of the transportation system. Alternatives may include long-term prospects for road pricing and for privatization as well as immediate measures aimed at reinforcing positive features of the present scheme.
- Identify institutional and technical obstacles that may hinder needed finance reforms and recommend a transition strategy to new finance arrangements if reform appears necessary.

is used here, a viable funding arrangement is one that will retain the capacity to fund transportation programs at an inflation-adjusted rate comparable with that of the past 20 years. In that period, revenues were sufficient to fund growth in highway spending and capacity and some improvements in service but not to prevent growing highway congestion.

Implicit in the charge is a broad definition of the scope of the transportation finance system. The system includes three elements: the schedule of fees or spe-

cial taxes that governments or other operators collect from users of highways and public transit; the sources of funds for transportation programs (which may include dedicated user fees, other dedicated revenues, general fund appropriations, and grants from other governments); and finally, the institutional arrangements and rules that determine budgets, spending priorities, and the distribution of responsibilities among levels of government. The impetus for this study was concern for the viability of present highway user fees as a revenue source; therefore, the committee has considered transit finance primarily insofar as it is linked to highway user fees. A prominent feature of the present finance system is the dedication of portions of federal and state highway user fee revenues to transit.

The committee assumed that short-term as well as long-term opportunities for improvement in finance arrangements were within its charge. A transition to some form of road pricing or direct mileage-based charges is viewed favorably in the state finance studies cited above and may be gaining recognition as the desirable eventual outcome. However, it is important not to neglect measures aimed at reinforcing the positive features of the present system. In the short term, dependence on fuel taxes and vehicle registration and license fees as revenue sources for transportation will continue.

Highway finance practices have consequences for environmental quality and energy consumption, but they have not been examined in this study. As the report will describe, one of the failings of present practices is that, although revenues from the fees and special taxes motorists pay cover most highway agency expenditures to build and operate roads, fees do not reflect other public costs of road travel, such as congestion delay and automotive pollution. The result is that road users make many trips that cost the public more to provide than they are worth to the traveler. A system for road use metering and mileage charging (a concept described in Chapter 5) could correct this failing, if public officials chose, by charging fees that approximated the actual costs of trips, taking into account the time and place of travel.

Within the present framework of highway user fees, proposals have been made to impose a pollution charge in the form of an increase in the fuel tax as a way to reduce automotive pollution costs. Before enacting such a tax, governments would have to consider the costs of overcharging vehicles that produce little pollution and travel in areas where pollution costs are low. A pollution tax would also complicate administration of the present user fee finance system, because history suggests a tendency for the revenue from taxes paid by road users to be devoted to road building eventually, regardless of the original intent. Finally, fundamental change in road user charges and the means of paying for roads would have important impacts on land use. Governments will need to consider such impacts as the transportation financing system evolves.

Partially or entirely replacing fuel taxes with fees based on mileage would reduce or eliminate the incentive that fuel taxes provide to motorists to choose

more fuel-efficient vehicles or otherwise conserve fuel. If fuel taxes are reduced in the future, the impact on fuel consumption should be recognized and consideration given to the need for offsetting actions, if the outcome appears contrary to goals of U.S. energy policy. (Of course, a mileage-charging scheme could incorporate conservation incentives.) A mileage-charging scheme that incorporated peak charges would have an important impact on energy consumption through its influence on congestion, travel, and land use. These effects have not been examined in this study. As will be argued in Chapter 4, the most cost-effective taxes for promoting petroleum conservation would be broad-based taxes applied equally to all petroleum consumers.

Lack of information makes definitive responses to all the questions raised in the study charge impossible. Projections of technology and energy futures are inherently highly uncertain. There is little systematic information on how the existing structure of charges, subsidies, and grant programs affects the decisions of users and transportation agencies. Information on the benefits and costs of highway investments and other transportation programs is fragmentary because agencies do not routinely conduct rigorous economic evaluations of their projects.

Because of this information gap and lack of experience with some of the reform measures that have been most prominently proposed, any specific and detailed recommendation for a new transportation finance system would be premature. Preparation for long-term reform will require basic research, planning, the promotion of informed public discussion, and early implementation of new approaches where circumstances permit, with the goal of learning from experience. A strength of U.S. transportation programs in this respect is the variety of conditions, experience, and practices among the states, which provide a natural laboratory for problem solving. The committee's conclusions and recommendations are to point out opportunities in these directions.

GUIDELINES FOR FINANCE ARRANGEMENTS

The study charge calls for evaluating the present transportation finance system and alternatives. This task requires criteria for comparison and an understanding of the goals of the finance system. Chapter 3 reviews methods and criteria that have been used to evaluate finance practices. In this introductory chapter it is appropriate to state certain premises that the committee believes should underlie the evaluations:

1. *Finance arrangements are central to the performance of the transportation system.* Choices about fees and taxes charged to users and about funding sources are critical not only to the feasibility of a transportation project or program but also to the likelihood of its success. The finance system is a

major influence on decisions about which projects and services are provided and how existing facilities are utilized. Therefore, any fundamental change in finance arrangements (e.g., replacing current user fees with fees of a different form) would strongly affect transportation system performance. Decisions on finance also determine the distribution of the costs and benefits of transportation programs. Finance alternatives should be evaluated in terms of these impacts.

2. *Efficiency is an important test of finance options.* The first test that should be applied to a proposed finance reform is whether it would tend to promote efficient investment and operation. That is, finance arrangements should encourage investments in the transportation system that yield economic benefits and discourage investments that do not, and they should encourage operating practices on existing facilities such that service is provided to those who value the service more highly than the cost of producing it and is not provided to others. The cost of transportation services includes congestion, environmental costs, and accident costs. Nearly any change in the finance system—adjustments in highway user fees, changes in the dedication of particular revenues to particular uses, or changes in grant rules—will affect efficiency.
3. *Pricing is a means to allow users to express what they want from the transportation system.* Pricing means a system of imposing charges on users in which each user recognizes a connection between decisions to use the transportation system and the charges incurred and the operating agency sets the charges on the basis of the cost of providing service to the user. The present highway user fee scheme of fuel taxes, registration fees, and licensing fees is an imperfect form of pricing. In a more refined scheme, such as the proposals for mileage charges cited above, the fee would be much more closely matched to the cost of each trip. The intent of pricing should be to give consumers the information they require to make efficient choices, rather than to dictate choices. In general, the price-setting process should not set targets for mode shares, congestion or pollution levels, or land use patterns and then adjust fees until the targets are reached. Rather, fees should be set according to costs, and travelers should be allowed to choose their preferred modes, congestion levels, and locations for activities. [The relevant costs and methods of measuring them were identified in the report of an earlier TRB committee (TRB 1996).]
4. *There are advantages in aligning the responsibilities of the federal, state, and local governments so that the lowest level of government that represents the parties directly benefiting from a transportation facility takes responsibility that the facility is funded and provided.* If this rule is followed, then the government responsible for the facility is accountable to the beneficiaries, who

also pay for it through their taxes and fees, and thus transportation priorities are more likely to correspond to the services that beneficiaries value and are willing to pay for. It does not follow from this guideline that the federal government must necessarily provide all facilities that serve national needs. State and local governments have shown that they are willing to provide many facilities of national significance as long as local residents do not have to subsidize them.

Consideration of the division of responsibility among the federal, state, and local governments for providing and funding roads and transit is an essential element of the committee's charge to identify alternatives to present finance arrangements. The present division of responsibility in large part reflects the character of funding sources. Lack of practical means for local governments to charge users of their roads, and especially of means for charging users from other jurisdictions, has been a primary reason for involvement of the federal and state governments in local transportation, and part of the justification for federal aid to states has been similar limits on state revenue-raising capacity. As governments pursue reform of transportation finance, the simple substitution of new revenue sources for the existing ones while leaving these institutional arrangements unchanged may not be possible. In particular, adoption of systems to directly charge motorists for road use (such as the Oregon mileage-charging proposal described above or expanded use of other forms of tolls) would compel a reexamination of federal, state, and local roles. State and local governments would expect to control revenue directly generated by the roads they own and operate and to control pricing on those roads. The new revenue-raising capacity would diminish the rationale for intergovernmental aid. To the extent that local and state governments have mechanisms to charge all users of the roads they operate, rather than just their own residents, the need for involvement of higher levels of government is lessened.

In most public discussions of transportation finance, the desire to increase revenue in order to serve defined needs is identified as the primary motivation for searching for finance alternatives. The state transportation finance studies summarized in the first section of this chapter are examples: the studies project that existing sources will not yield sufficient revenue to maintain desired levels of spending. Revenue adequacy is a primary federal concern as well. The Federal Highway Administrator, explaining the need for finance reform, has stated that "it is politically untenable to increase [fuel] taxes to the level necessary to support today's and tomorrow's needs" (Orski 2004). Revenue-raising capacity is certainly a relevant criterion for evaluating tax alternatives, and it is responsible for public officials to view finance as the art of finding money for programs they believe the public wants.

However, the list of the committee's evaluation guidelines above does not refer to revenue adequacy. The committee has not interpreted its task as finding revenue mechanisms that will support an increased level of spending for transportation. Information about highway benefits and costs is incomplete, and only highly imprecise estimates of correct spending levels are now possible. More important, there is no certainty that finance reform in the direction of improving the efficiency of the transportation system would necessarily raise more revenue than existing arrangements. The reformed system would remain subject to many of the external political and economic constraints that limit the revenue potential of the present system, although the public might be willing to pay more for a transportation system that worked better. Finance reform could improve performance to the extent that expenditures that appear to buy little improvement today might be more attractive.

Even though it would be difficult to predict the revenue consequences of developing new user fees to supplement or replace existing ones, it is reasonable to expect that the performance of the system would improve over time if fees more closely reflected costs. Transportation agencies would have more information about user benefits, and the pressures arising from budget constraints and user preferences would tend to encourage better investment and operating decisions.

OUTLINE OF THE REPORT

The remainder of this report is organized as follows. Chapter 2 describes present highway and transit finance arrangements and trends in finance practices. The chapter considers whether the viability of the present finance system is threatened by trends in reliance on user fees, legislative adjustments to fees, or revenue yield. Chapter 3 summarizes available information on the performance of the finance system for highways and transit at the federal, state, and local government levels—whether appropriate resources are available and are being devoted to the most beneficial uses, and the degree to which the system incorporates incentives for prudent use and management of facilities. The benefits of reform depend on how well present arrangements are working. Chapter 4 reviews projections of energy prices, motor vehicle technology, and fuel economy and considers the likelihood of future government interventions to regulate fuel consumption or pollutant emissions that could affect transportation revenue sources. Thus the merits of the three arguments for reform of the system identified above—a diminishing tax base, erosion of the user fee finance principle, and the opportunity to improve efficiency—are assessed in Chapters 4, 2, and 3, respectively.

Chapter 5 describes proposals for fundamental changes in revenue sources, including mileage charges and expansion of toll roads. Chapter 6 reviews a variety of proposals for improvements within the established framework of user fees and

other finance practices. Finally, Chapter 7 presents the committee's conclusions and recommendations.

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Abbreviations

CRC	Citizens Research Council of Michigan
CTI	Commission on Transportation Investment (California)
TRB	Transportation Research Board

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Present Finance Arrangements

The first two sections of this chapter describe features of the finance system for highways and transit in the United States today, including the fees and use-related taxes that users of the facilities pay; levels of spending; sources of funds; responsibilities of federal, state, and local governments; and decision making on budgets, project selection, and operations. As explained in Chapter 1, the concern that adherence to the original principles of the finance system has eroded over time has been one of the motivations to seek finance reforms. Therefore, the final section of the chapter examines developments that may affect the viability of the finance system. These include trends in the share of highway user fee revenues applied to purposes other than highways, adjustments of user tax rates to allow for inflation and changes in costs, devolution of transportation responsibilities to local governments, reliance on revenues other than user fees, and revenue adequacy and stability.

Examination of the workings of the present finance system is a necessary first step toward designing improvements. If the present system is producing unsatisfactory results, the structural sources of problems should be identified, and if the system is performing well, it may be possible to build on its strengths. Chapter 3 will consider the problem of evaluating the performance of the finance system.

HIGHWAY FINANCE

This section presents aggregate nationwide data on spending for highways, fuel taxes and other taxes and fees paid by highway users, and other sources of funds for highway programs. The data and definitions are mainly from the Federal Highway Administration's (FHWA's) annual compilation in the *Highway Statistics* publication series. The final two subsections briefly outline administration and

decision making in the federal-aid program and state highway programs and the historical origins of the present system.

Spending

Governments spent $136.4 billion to construct and operate highways in the United States in 2004 (FHWA 2005a, Table HF-10). Highways are predominantly an activity of state governments: 60 percent of all spending and 72 percent of all capital spending are by the states (Table 2-1). Highways accounted for 9 percent of state and 4 percent of local general government direct expenditures in 2003 (U.S. Census Bureau 2005a).

The capital spending share of total expenditures has declined since the 1960s and 1970s. Since at least the 1980s (earlier data are not available), the fraction of construction expenditures that is classified by the states as new construction (that is, substantially new roads rather than reconstruction or upgrades of existing roads) has declined. For capital expenditures by state governments on roads other than local roads, 39 percent was new construction in 1981, 33 percent in 1991, and 19 percent in 2004 (FHWA 1997, Table SF-212A; FHWA 2005a, Table SF-12A).

Funding Sources

State and local governments dedicate, by law, certain revenues from highway user fees and other taxes to pay for highways. They also receive federal grants designated for highways and issue bonds with the proceeds dedicated to highways. These sources of funds are described below. If they fall short of highway spending, the difference is charged to general funds.

Identifying the sources of funds for specific government expenditures is inherently ambiguous because revenues are fungible. To say that highway expenditures come from a particular revenue source may be taken to mean that

TABLE 2-1 Highway Spending by Level of Government and Function, 2004 (Percent Distribution) (FHWA 2005a, Table HF-10)

	Federal	State	Local	Total
Capital outlay	1	37	13	52
Maintenance and traffic services	–	11	16	27
Administration, research, and law enforcement	2	12	8	22
Total	3	60	37	100

NOTE: Payments of interest on debt and bond retirements are excluded. Spending does not include grants to other levels of government for highway purposes.

when revenue from the source increases, spending increases, and that spending falls when revenue falls, in like amounts (possibly with a time lag when there is a trust fund, but eventually keeping spending and revenue in balance). The connection between legally dedicated revenues and spending usually is imperfect in the highway program and in similarly funded government activities. For example, it will be seen below that when highway user fee revenues fell sharply in the 1970s, highway spending slowed, but governments made up part of the shortfall from other sources. The structure of transportation finance is best understood as the result of two independent policy decisions: first, how users of transportation facilities should be charged; and second, what connections should be established between the revenue raised from users and the level of spending on facilities and services.

User Fees

Total receipts of highway user revenues as defined by FHWA were $106.8 billion in 2004. FHWA defines this quantity to include revenue from any tax or fee paid by owners or operators of vehicles that use public roads, as a consequence of their use of the roads, and that is not paid by others. For example, FHWA classifies revenue from motor fuel taxes that apply only to fuel consumed on public roads as a user revenue, but not sales tax collected on gasoline if the state collects the tax at the same rate on all gasoline sales regardless of use. The definition does not consider whether the revenues are dedicated to road expenditures (FHWA 2004, IV-4–IV-5). In this chapter the FHWA definition is used. Box 2-1 explains how the term "highway user fee" is used in this report.

Fuel taxes are the major user fee and account for nearly two-thirds of the total (Table 2-2). The share of user fee revenue derived from fuel taxes has been stable over the past 40 years except for a dip in the late 1970s to early 1980s. Most revenues in the "other user taxes and fees" category in Table 2-2 are from vehicle registration and operator license fees. The majority of state and local user fee revenues are from fuel taxes. However, 13 states, including California, Illinois, Michigan, New Jersey, and Texas, collected more in registration and license fees than in fuel taxes in 2004 (FHWA 2005a, Tables MV-2, MF-1). Tolls are collected on roads, tunnels, or bridges in 33 states, although 38 percent of all tolls paid in 2003 were collected in two states, New York and New Jersey. Nearly all toll facilities in the United states are operated by publicly controlled special authorities.

The large discrepancies between the share of user fees collected by level of government and spending shares by level of government (shown in Table 2-1) reflect intergovernmental transfers and application of funds other than user fee revenues to highway purposes. The federal government distributes nearly all its revenues to the states and local governments through the federal-aid highway program and federal mass transit assistance, and states distribute a portion of their user fee revenues to local governments.

BOX 2-1

Highway User Fees

FHWA defines the term "highway user revenues," in part, as follows (FHWA 2004, IV-4–IV-5):

> [Revenues generated by] taxes and fees imposed on the owners and operators of motor vehicles for their use of public highways are . . . highway-user revenues. . . . The clearest example of a highway-user tax or fee is a toll. . . . Most motor fuel taxes are classified as highway-user taxes. . . . For motor fuel revenues to qualify as a highway-user revenue . . . , a motor-fuel tax must be levied per unit of volume. . . . It must also apply only to motor fuel [as] opposed to all petroleum products, . . . or provide a separate rate for motor fuel. . . . Motor-vehicle registration fees, certificate-of-title fees, driver-license fees, and other miscellaneous vehicle fees are all highway user taxes. . . . Weight–distance taxes, oversize–overweight permits and trip permits are even more directly related to highway use. . . . Those taxes and fees that target a broader base than highway users are considered to be a part of the general tax structure of the State, and are not considered to be highway user taxes. . . . State sales taxes imposed on motor vehicle sales typically are not highway user revenues. . . . When motor vehicle sales are charged a separate tax rate from that imposed on general sales transactions, the motor vehicle sales tax is considered highway user revenue.

Definition of highway user revenues or of highway user fees (as the payments are sometimes called) is complicated by the great diversity of federal, state, and local tax provisions that must be taken into account. The correct definition depends on the reason that importance is placed on motorists paying directly for their use of highways. If user fees are seen as a means of promoting economic efficiency, the definition should be that user fees are payments that function to some degree like market prices (i.e., payments that reflect the cost of providing service and thus provide an incentive to avoid wasteful use of highways). Historically, the user fee–based highway finance system was not created with this efficiency consideration in mind, but rather because it was seen as a stable and equitable mechanism for raising a desired level of revenues. Payments are related to use of roads and to costs occasioned, but the correspondence is very imperfect.

Most kinds of payments listed in the FHWA definition of highway user revenues (exceptions include tolls and trip permit fees) are taxes. It may be objected that the term "user fee" (which is employed in this report) is a mischaracterization of the special taxes charged to road users because it implies a greater government obligation to road users than actually exists. A fee is a payment in return for receipt of a service, while a tax can be defined as a mandatory payment to government for public purposes, in return for which the government does not commit itself to provide any specific service to the payer. By these definitions, postage stamps and tolls on government-operated roads are fees rather than taxes. In the case of motor fuel excise taxes, the government has no contractual obligation to provide road services in return for tax payments, although it is commonly argued that a commitment in the form of a political understanding at the time of enactment does exist (Patashnik 2000, 2). Federal and state budgeting rules that tie highway spending to user fee revenues reinforce this supposed commitment.

This report accepts the FHWA classification of payments qualifying as highway user revenues and refers to these payments as highway user fees. By this classification, highway user fees include all excise taxes paid on highway fuels, vehicles, and parts that are not paid on similar purchases for nonhighway use; highway vehicle registration and permit fees; driver's license fees; and tolls. For some state taxes, the FHWA classification may be questionable; however, the amounts involved in such cases do not appear to be important. The classification does not depend on whether the revenue from the tax is dedicated to any particular use.

TABLE 2-2 Highway User Revenues by Level of Government and Source, 2004 (Percent Distribution) (FHWA 2005a, Tables HF-10, SDF, LDF, FE-10)

	Federal	State	Local	Total
Fuel taxes	31	32	1	64
Tolls	–	6	2	8
Other user taxes and fees	3	24	1	28
Total	34	63	4	100

In the past 40 years (a period nearly matching the history of the federal-aid highway program in its present form), some marked swings have occurred in finance patterns, particularly in the late 1970s and early 1980s (Table 2-3). In those years, constant-dollar user fee collections fell precipitously as a result of high inflation, slow growth in highway travel caused by high fuel prices and recession, and improvements in fuel economy caused by regulation and high fuel prices. Spending fell in the same period, especially state government capital spending, at least partially as a result of reduced revenues, although the capital spending decline may also reflect the completion of major components of the Interstate system in the period. Congress increased federal excise tax rates in the 1982 highway act, and many states increased rates in the same period, so by 1991 the ratio of revenues to expenditures had returned to its level of the 1960s. Since the late 1990s the ratio has been declining.

The predominant role of state governments in highway finance and the ratio of federal aid to total spending have not changed greatly over the period shown in Table 2-3. The ratio of federal highway aid received by state and local governments to total highway expenditures has been 20 to 25 percent for most of the period. The ratio of federal aid to highway expenditures (22 percent in 2004; see Table 2-3) is smaller than the ratio of federal highway user fee revenue to total user fee revenue (34 percent in 2004; see Table 2-2) because the federal government devotes a larger share of its user fee revenue to transit than do state and local governments.

Federal excise tax rates are 18.4 cents per gallon for gasoline and 24.4 cents per gallon for diesel fuel (FHWA 2005a, Table FE-21B). Until 2005, gasohol (a blend of gasoline and ethanol) was taxed at a rate of 13.2 to 15.4 cents per

TABLE 2-3 Historical Trends in National Highway Spending, User Fee Revenue, and Highway Travel (FHWA 2002; FHWA 2005a; FHWA 1997)

	1961	1971	1981	1991	2001	2004
Expenditures ($, billions)	11	21	40	74	123	136
Expenditures (2001 $, billions)	52	75	71	90	123	128
State govt. expenditures (percent of total)	69	69	60	62	64	60
Capital outlay (percent of expenditures)	64	59	49	50	53	52
Federal aid (percent of expenditures)	25	24	27	20	23	22
Highway user fee revenues (2001 $, billions)	44	64	46	77	99	100
(User fee revenues)/expenditures (percent)	84	85	66	85	80	78
Highway travel (vehicle miles, trillions)	0.7	1.2	1.6	2.2	2.8	3.0

NOTE: Payments of interest on debt and bond retirements are excluded. Price index is gross domestic product implicit price deflator (BEA 2002, 135; BEA 2005, 188–189).

gallon, depending on ethanol content. The gasohol excise is now collected at the same rate as the gasoline tax, and gasohol producers are paid a rebate from the general fund. In addition, federal excise taxes are collected on tires, large trucks, and trailers, and trucks pay the annual federal heavy vehicle use tax. Sales-weighted average state fuel tax rates in 2004 were 19.2 cents per gallon for gasoline and 20.0 cents per gallon for diesel fuel (FHWA 2005a, Table MF-121T). Most states tax gasohol at the same rate as gasoline. Registration fees and miscellaneous other federal, state, and local taxes and fees (that is, all user fees except fuel taxes and tolls) averaged $125 per registered vehicle in 2004 (FHWA 2005a, Tables SDF, LDF, FE-210, VM-1).

The average of all user fees paid per vehicle mile of highway travel declined (in 2001 dollars) from $0.06 per mile in the 1960s to $0.03 per mile by 1980 (Figure 2-1). The average fee has recovered somewhat, to $0.034 per mile today, but remains well below the peak of the 1960s. Trends in tax rates are examined in the final section of this chapter.

State and federal tax and fee schedules discriminate between light and heavy vehicles in an effort to collect revenues from different kinds of vehicles proportionate to relative responsibilities for highway costs. At the federal level, a 12 percent

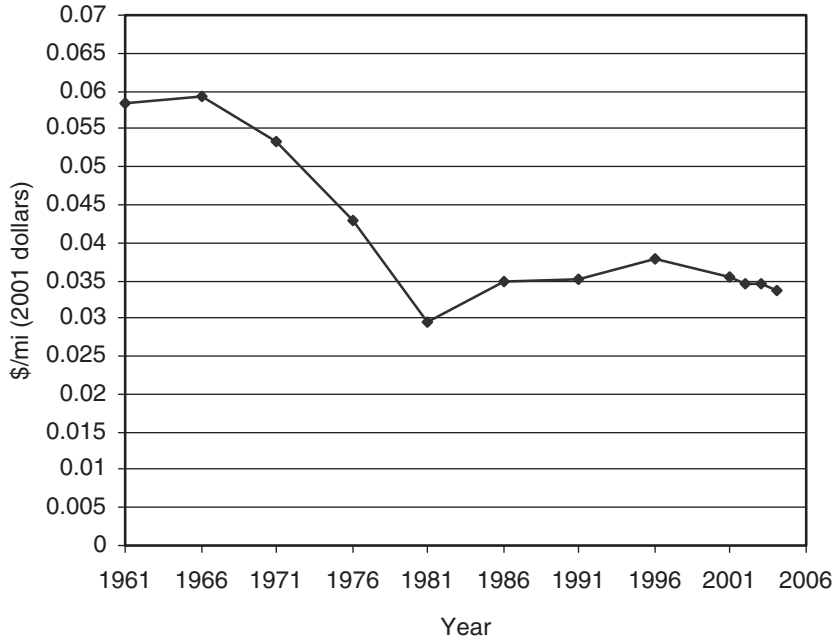

FIGURE 2-1 Average user fee, 1961–2004. (Sources: FHWA various years, Table HF-10; FHWA 1997, Table HF-210.) Price index is gross domestic product implicit price deflator (BEA 2002, 135; BEA 2005, 188–189).

excise tax on trucks over 33,000 pounds gross weight and on trailers and a per pound excise on tires are credited to the Highway Trust Fund, and trucks over 55,000 pounds gross weight pay an annual federal fee of from $100 to $550 depending on weight (FHWA 2005a, Table FE-21B). States also impose higher fees on trucks, and a few states charge trucks a tax based on mileage. Large trucks pay higher average fuel tax per mile than light vehicles because they have lower fuel efficiency. According to the 1997 U.S. Department of Transportation (USDOT) highway cost allocation study, the average total user fee per mile paid to all levels of government is six times higher for a combination truck than for an automobile. Combination vehicles, which account for 5 percent of all vehicle miles, pay 19 percent of all user fees in the USDOT estimates. The cost allocation study estimates did not count federal motor fuel tax revenues not credited to the Federal Highway Trust Fund as user fees and so understate user fees according to the definition used elsewhere in this chapter (USDOT 1997, Tables II-6, IV-8, IV-11). Proposals for better aligning average fees with costs for automobiles and trucks are described in Chapter 6.

Other Revenue Sources

State and local governments legally dedicate the revenues from particular taxes in addition to highway user fees to pay for transportation programs. Such taxes are most commonly local property taxes and state and local sales taxes (Goldman and Wachs 2003). Revenue from taxes dedicated by law to highway use, other than highway user fees, was $15.4 billion in 2004, 11 percent of all highway spending (FHWA 2005a, Table HF-10). This ratio has been nearly constant over the past 40 years, although the portion derived from taxes other than property taxes, including dedicated state sales taxes, has been growing.

In addition to the revenue of legally dedicated taxes, state and local governments appropriate funds from general revenues each year for spending on roads. Comparing these general fund appropriations with total spending is difficult, because many jurisdictions deposit some part of their highway user revenue into their general funds and then make appropriations for highways out of general funds. Also, the federal government distributes about $1 billion per year from general fund appropriations to state and local governments for highway purposes through grant programs of various agencies (FHWA 2005a, Table FA-5). Highway user fee revenue (whether dedicated to highways or not) equaled 78 percent of highway spending in 2004, and revenue from dedicated taxes other than user fees equaled 11 percent, so the net contribution from general revenue may be defined as the remaining 11 percent.

Debt Finance

Highway finance in the United States is commonly described as a pay-as-you-go system, which is to say that debt finance is little used (except for toll roads)

and spending tends to track revenues. The revenue figures in Tables 2-2 and 2-3 exclude bond issue proceeds, and the spending figures exclude interest payments and debt retirement. State and local government bond issue proceeds for highway uses in 2004 (excluding notes with maturities of 2 years or less) were $15.8 billion, equal to 12 percent of spending. The volume of bonds issued for highways has fluctuated over the past 40 years, but this is a typical ratio for the period. Interest payments and bond retirements in 2004 were $13.8 billion (FHWA 2005a, Table HF-10). Toll facilities are major issuers of bonds.

Federal and State Highway Program Structure

The federal-aid highway program distributed $28.3 billion to the states in 2004 for spending on highway construction, equal to 21 percent of all highway spending that year (FHWA 2005a, Table HF-10). The rules of the program affect the total of highway spending, the projects selected, and the performance of the highway system. The main features of the federal-aid program are as follows (FHWA 1999):

- Periodic federal surface transportation acts provide multiyear funding authorizations for federal highway and mass transportation capital grant programs and set program rules and highway user taxes. Federal rules include standards with regard to design, maintenance, and safety for projects making use of federal aid.
- The amounts authorized for each year in the surface transportation act are distributed annually to the states. Most funds are apportioned according to formulas specified in the act, within categorical programs. [The 2005 reauthorization legislation—Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—funds six program categories receiving $1 billion per year or more each and several smaller ones.] Apportionment formulas include such factors as each state's shares of highway lane miles, vehicle miles of travel, and Highway Trust Fund revenue collections. The surface transportation acts provide contract authority, that is, state spending that incurs a federal obligation may take place as soon as funds are apportioned each year. This is in contrast to most federal programs, in which amounts authorized may not be used until Congress enacts a second law appropriating funds to pay for authorized spending.
- Federal-aid funds are available to the states for 4 years after they are distributed, but Congress regularly enacts annual limitations on the total amount of federal-aid funds that may be obligated in the year, so states may not be able to use the entire amounts authorized. The provision of contract authority in multiyear surface transportation acts, together with the annual obligation limitations, is regarded as granting the states greater certainty and flexibility than would reliance on annual appropriations.

- Funds are appropriated annually to reimburse the states for the federal share of expenditures (80 or 90 percent for most kinds of projects, specified in the law) that the states have made on eligible projects.
- The highway user taxes collected by the federal government are deposited in the Federal Highway Trust Fund (divided between a highway account and a mass transit account), and payments to states are withdrawn from the fund. The Highway Trust Fund is a bookkeeping device to make apparent the relation of user fee collections to spending. Authorizations in the surface transportation acts are limited by the balance in the fund and the projected deposits from user tax revenues. The balance in the highway account of the fund stood at $14.6 billion in 2004, the equivalent of about 6 months of disbursements (FHWA 2005a, Tables HF-10, FE-210).

Because the states are directly responsible for most highway spending, state procedures with regard to programming and budgeting have great importance for the performance of the transportation system. Most states have finance arrangements analogous to those at the federal level, including trust funds and dedication of user tax revenue to highway uses. Only Alaska, Georgia, New Jersey, and the District of Columbia credit most highway user revenues to general funds rather than earmarking them for highways, transit, or other special purposes (FHWA 2005a, Table DF).

Federal-aid highway program capital grants plus required matching funds equal approximately 52 percent of all state and local government highway capital spending. Federal-aid rules do not dictate state project selection (with the exception of certain projects specifically identified by Congress, as described below), but they do influence the process. The mechanisms of influence include the following:

- As a practical first priority in budgeting, states must provide sufficient matching funds, by program category, to ensure that all available federal aid is obtained.
- The federal government imposes design standards on federal-aid projects and oversees design and construction.
- Each federal-aid project must be listed in the State Transportation Improvement Program (STIP) for the state. Federal regulations define the content of the STIP, a multiyear capital program that lists all federal-aid highway and transit projects by year and in priority ranking, with costs and funding sources identified. The STIP must show that the spending program for federal-aid projects is consistent with expected sources of funds. Federal-aid projects in metropolitan areas must be from improvement programs approved by the local metropolitan planning organizations. Projects must be shown to be in conformity with the State Implementation Plan for attaining federal air quality standards, and the STIP must list non-federal-aid proj-

ects that could affect air quality (USDOT 2003; Wisconsin Department of Transportation 2004).

- Although only construction, reconstruction, and certain major maintenance activities are eligible for federal aid, federal law requires states to maintain roads constructed with federal aid to specified standards. States also are required to have management systems for pavements, bridges, congestion, and safety (23 USC 303). These involve systematic collection of data on physical condition and performance and formal procedures for planning and evaluating maintenance and construction schedules.

Despite federal requirements, a state with funds for capital spending in excess of federal-aid matching requirements has a degree of flexibility to minimize the impact of the rules on its ability to carry out projects according to its own priorities (TRB 1987, 49–64). Projects that have no federal-aid funding do not have to comply with many federal requirements (for example, design requirements), and the smaller the federal-aid share of total state spending is, the less importance the division of federal aid into the various program categories has for actual state spending priorities. The effects of the federal-aid program rules on state spending and project selection have never been comprehensively studied. Some possible impacts are discussed in Chapter 3.

TRANSIT FINANCE

Most transit services in the United States are operated by special-purpose authorities controlled by local and state governments. Transit was primarily a private-sector industry until the 1960s, but publicly owned systems carried 50 percent of all passengers by 1967 and 94 percent by 1980 (APTA 1981, 27). The industry's major sources of funds are passenger fares; other revenue related to transportation operations (e.g., from advertising and chartered buses); revenue from special taxes dedicated to transit; and other federal, state, and local government aid (Table 2-4).

Federal grants are about one-sixth of all funds expended; the federal share has declined from a high of nearly one-third in the early 1980s (Table 2-5). Most federal funding depends on revenue from the federal highway motor fuel tax, including the $0.0286 per gallon share dedicated by Congress to the Mass Transit Account of the Highway Trust Fund as well as funds in certain categories of the federal-aid highway program that states and localities can transfer to transit. Federal assistance includes formula grants for capital and operating expenditures apportioned among urbanized areas according to population and transit service characteristics and discretionary capital grants (in the New Starts and Bus Capital programs) distributed to specific projects selected by Congress or the Federal

TABLE 2-4 Public Transit Sources of Funds, 2000 (Percent of Total Funds)

Item	Percentage
Fares	25
Other revenue from transport services	3
Federal grants	
From dedicated federal fuel tax revenue	14
From general fund	3
State government sources	
From general revenue	7
From dedicated sales tax revenue	2
From other sources	9
Local sources	
From general revenue	8
From dedicated sales tax revenue	14
From other sources	16
Total	100

SOURCES: USDOT n.d., p. 6-22; FTA n.d. a, Table 1. [The original source is the National Transit Database (NTD), compiled by USDOT from transit agency reports. The NTD shows that dedicated state and local fuel taxes were the source of $500 million of transit funding in 2000. In contrast, reports of state and local governments to USDOT tabulated in *Highway Statistics* (Tables SDF, LDF, HDF) show $1.3 billion in state fuel tax revenue and $3.2 billion in total state and local highway user fee revenue distributed to transit in 2000 (in addition to $5.1 billion in federal highway user revenue to transit). Highway user fee revenue devoted to transit at local officials' option, rather than as a matter of law, may account for some of the discrepancy.]

Transit Administration. The required state and local matching share for federal grants is 20 percent (that is, at least 1 state or local dollar for every 4 federal dollars) for capital projects and 50 percent for operating assistance (APTA 2005, 1–4; USDOT n.d., 6-23–6-33). Eighty percent of federal assistance received in 2001–2003 was for capital expenditures (APTA 2005, Tables 55, 66).

State and local funding derives from dedicated taxes and general revenue. Sales taxes are the most important form of state and local dedicated tax and accounted for 16 percent of transit funding in 2000 (Table 2-4). State and local highway user fee revenue devoted to transit was $3.2 billion in 2000, equal to 9 percent of all transit expenditures, and $4.4 billion, 11 percent of expenditures, in 2003. The total of federal, state, and local highway user fee revenue devoted to

TABLE 2-5 Trends in Transit Expenditures, Sources of Funds, and Transit Use

	1961	1971	1981	1991	2001	2003
Expenditures ($, billions)	1.5	2.2	12.7	22.1	36.7	41.3
Expenditures (2001 $, billions)	7.4	8.0	22.2	27.0	36.7	39.8
Capital expenditures (percent of total)				33	31	32
Federal grants (percent of expenditures)	0	13	32	17	19	17
Fare revenue (percent of expenditures)	88	74	21	27	24	22
Average fare per trip (2001 $)	0.72	0.87	0.57	0.85	0.92	0.93
Average expenditure per trip (2001 $)	0.83	1.17	2.68	3.14	3.80	4.22
Passenger trips (billions)	8.8	6.8	8.3	8.6	9.7	9.4

NOTE: Price index is gross domestic product implicit price deflator (BEA 2002, 135; BEA 2005, 188–189). Expenditures for 1991–2002 are the sum of capital and operating funding received from all sources. The American Public Transportation Association does not report capital funding or expenditures before 1988; 1961–1981 expenditures in the table were estimated on the basis of operating funding and estimates of total expenditures prepared by Wilson (2001, 8–11). Passenger trip data before 1981 are not strictly comparable with later years' data because of changes in the definition of a trip and in data collection procedures (APTA 1992, 64).

SOURCES: APTA 2005; APTA 1992; APTA 1978.

transit equaled 24 percent of transit expenditures in 2000 and 25 percent in 2003 (FHWA 2001; FHWA 2005a, Table HF-10; APTA 2005, Tables 55, 66). The section below on nonhighway uses of highway user fee revenue further describes transit applications of these revenues.

Passenger fare revenues have equaled about one-fourth of annual expenditures since the 1980s. Transit ridership and constant-dollar fares have been more or less constant over the past 40 years, while total and capital expenditures per passenger have risen (Table 2-5). These trends are in contrast to the experience of the highway sector: average highway user fees (per vehicle mile) have fallen over this period, but highway use has increased substantially and average public (Table 2-3) and private (Wilson 2002, 40) highway expenditures per vehicle mile have fallen.

The growth in transit spending without corresponding growth in fare revenue or federal assistance has stressed state and local government transportation budgets. Until the mid-1980s, revenue sources other than state and local government covered the majority of transit expenditure. (As Table 2-5 shows, fare revenue was sufficient to cover most operating and capital expenditures until the early 1970s; by 1981 fares had declined to 21 percent of expenditures but federal aid covered 32 percent.) However, by 2003 the share of spending covered by these sources had declined to less than 40 percent. (Fares remained at 22 percent but the federal-aid share had declined to 17 percent.) State and local subsidies to transit

reached $25 billion in 2003, an increase of 135 percent in constant dollars since 1981 (Figure 2-2). Ridership grew 14 percent in the same period (Figure 2-3).

Transit use and spending are highly concentrated in a small number of metropolitan areas. New York City Transit, the largest system, accounted for 30 percent of all U.S. transit passenger trips and 18 percent of transit spending in 2002 and received 10 percent of all federal transit assistance. The five largest systems in terms of ridership (the central systems in New York City, Chicago, Los Angeles, Washington, D.C., and Boston) had 49 percent of passengers and 33 percent of expenditures and received 27 percent of federal assistance. If independent suburban and commuter services are counted, these five metropolitan areas' combined share of nationwide ridership is well over half (FTA n.d. b).

COMPARISONS WITH OTHER INFRASTRUCTURE AND INTERNATIONAL PRACTICES

The preceding two sections described arrangements for financing highways and transit in the United States. In assessing alternatives to these arrangements, a broader perspective derived from comparisons with finance arrangements for

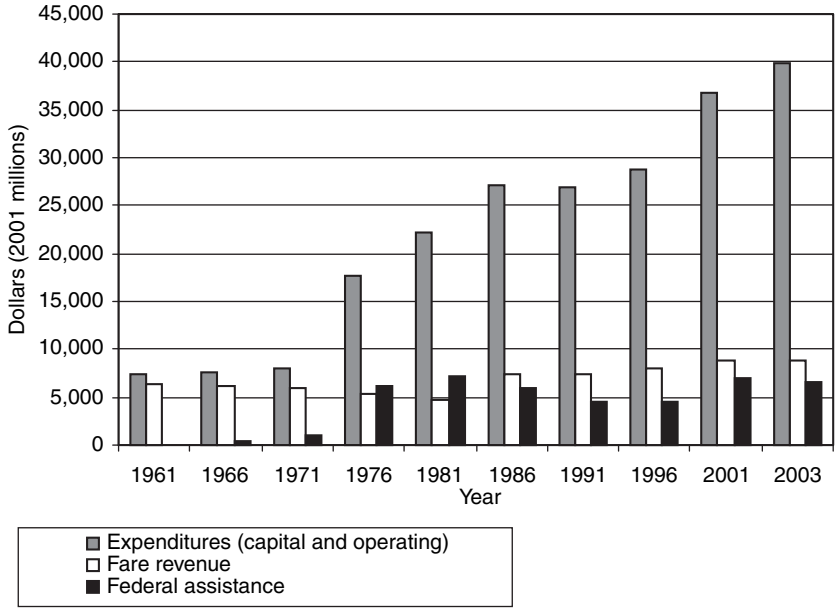

FIGURE 2-2 Constant-dollar annual transit expenditures, fare revenue, and federal assistance, 1961–2003. (Sources: APTA 2005; APTA 1992; APTA 1978.) Price index is gross domestic product implicit price deflator (BEA 2002, 135; BEA 2005, 188–189).

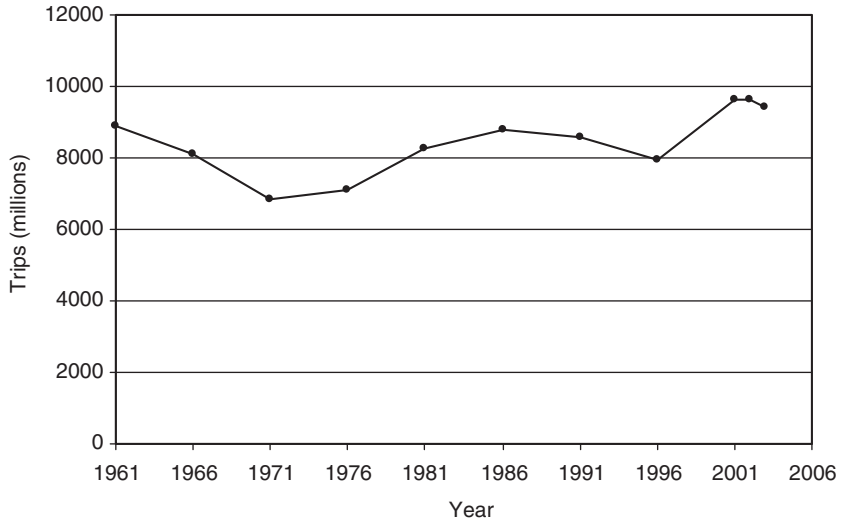

FIGURE 2-3 Annual unlinked transit passenger trips, 1961–2003. (Sources: APTA 2005; APTA 1992; APTA 1978.)

other U.S. public utilities and transportation systems in other countries may be helpful. The characteristic features of these arrangements include the degree of reliance on revenue from users and other sources, the structure of user fees, and the spheres of involvement of the national, regional, and local governments and of the private sector. Such comparisons can suggest options for alternative finance arrangements. They may reveal how alternative finance arrangements have influenced the performance of the various public utility sectors—the quality of services and the public return on investments. Comparisons also may provide some insight into why U.S. highways and transit are financed as they are—whether finance arrangements arise from intrinsic characteristics of these industries related to the costs of producing the services they provide or the nature or social significance of these services, or, alternatively, whether the arrangements are more the result of the historical development of the industries or of external factors.

The comparisons summarized in Tables 2-6 and 2-7—among highways, transit, and other government-provided infrastructure services in the United States and among highway systems in Europe and the United States—show that diverse financial arrangements exist. They suggest that differences in finance practices may arise more often from historical accident than from inherent differences among the industries. In the United States in 2002, governments spent $39 billion to construct and operate public transit, $133 billion for highways, $22 billion for airports and air traffic control, $1 billion for inland waterways navigation facilities, and $65 billion for local water and sewerage systems (Table 2-6). Local

TABLE 2-6 Sources of Funds and Expenditures for Public Water and Sewer (2001), Transit (2002), Highway (2002), Airport and Aviation (1999), and Inland Waterways Navigation (2002) Facilities

	Water and Sewer	Transit	Highway	Airport and Aviation	Inland Waterways
User fee revenue ($ billions)	56.6	8.6	100.5	21.1	0.1
Total expenditures ($ billions)	64.8	39.3	132.6	21.8	0.8
Capital		12.8	68.2		0.3
Operating		24.8	59.0		0.5
User fee revenue/expenditures	0.87	0.22	0.75	0.97	0.12
Federal grants and direct spending ($ billions)	3.2	6.6	32.9	10.7	0.8
(Federal grants and direct spending)/expenditures	0.05	0.17	0.25	0.49	1.0

NOTE: Water and sewer excludes federal water projects. Total expenditure amounts include interest on debt. Airport and aviation includes the federal air traffic control system.

SOURCES: FHWA 2003, Table HF-10; U.S. Census Bureau various years, Table 1; BTS n.d., Tables 2-A, 3-A, 13-A, 14-A; CBO 2002, 7; IWR 2004; CBO 2005, 94; APTA 2004.

governments are the direct providers of most transit, water and sewer, and public airport services; states provide the majority of highway services; the federal government operates air traffic control and the inland waterways. Infrastructure provided by the private sector accounts for no more than a small fraction of expenditures in all these industries. Federal grants and direct federal spending (in the years shown in Table 2-6) equal 25 percent of spending for highways, 17 percent for transit, 49 percent for airports and air traffic control, and 5 percent for water and sewer.

No rule that determines the extent of federal involvement or the extent to which public expenditures are covered by user fees in these industries is evident. Substantial federal involvement in highways and in airports and air traffic control and low involvement in water and sewer may be roughly consistent with the mix of national and local services that these systems provide. Federal grants to water and sewer were much higher in the 1970s and 1980s than today. The purpose of the grants was to reduce water pollution; the grants may have reflected the regional nature of pollution impacts (EPA 2003, 3). Federal involvement in transit is high compared with water and sewer, another mainly local service, but is declining over time.

Highways, local water and sewer, and airports and air traffic control are largely paid for by fees and taxes collected from users. (Airport revenues include

TABLE 2-7 Road User Revenues and Highway Expenditures in Europe

	France	Germany	United Kingdom	Western Europe
Sources of road user revenues (percent of total)				
Taxes related to vehicle ownership[a]	27	22	47	33[b]
Fuel tax	57	78	53	55
Tolls and permits	8	–	–	4
Other	8	–	–	8
Road user revenues[c] (ECU billions)		38.4[d]	23.3[d]	119.7[d]
Expenditures (ECU billions)		15.0	8.3	60.0
Revenue/expenditures		2.6	2.8	2.0
Distribution of expenditures by level of government (percent, 1990)				
Central	23	39	60	48[e]
Regional	12	15	–	12
Local	65	46	40	40

NOTE: ECU = European currency units; equal to about $1 in the period. Dash indicates negligible.

[a]Includes vehicle purchase taxes, import duties, and registration and license fees.

[b]Fourteen countries, about 1993.

[c]Includes fuel taxes, annual vehicle registration fees, tolls, and permit fees.

[d]For Germany and the United Kingdom, 1994; for Western Europe, 11 countries, various years.

[e]Seventeen countries.

SOURCE: Farrell 1999, 44–62.

fees paid by airlines and rents paid by concessions, which are indirectly derived from air travelers.) In contrast, in the years shown in Table 2-6, transit fare revenues covered 22 percent of expenditures of government-provided transit services, and waterway user fees (a tax on commercial towboat fuel) covered 12 percent of inland waterways navigation expenditures. Some of this variation reflects the relative ease of measuring and charging for individual uses. For example, the gap between highway user fee revenue and expenditures is in part the consequence of local governments' lack of practical methods of charging for use of local streets.

Road user fees and highway finance in Europe show some marked contrasts to U.S. practices. Most notably, revenues derived from road users greatly exceed highway spending, by 2:1 on average in western Europe and by up to 3:1 in some countries (for example, €38 billion in revenue versus €15 billion in expenditures in Germany and €23 billion revenue versus €8 billion expenditure in the United Kingdom in 1994) (Table 2-7). The relative importance of various kinds of fees

is roughly similar to that in the United States: fuel taxes generate over half of revenues; tolls on average generate 4 percent but up to one-eighth of the total in some countries. The national government is directly involved in road construction and operation throughout Europe.

Most European governments credit fuel tax and vehicle fee revenues to general funds, but Germany, Switzerland, the Netherlands, Belgium, and Greece dedicate specific shares of these revenues to roads; and the Netherlands, Belgium and Greece have set up infrastructure funds with dedicated revenues and with disbursements limited to certain types of projects (Farrell 1999, 59–61). A high percentage of expressway mileage in several European countries is tolled (88 percent in Italy and 82 percent in France in 1995), but because the expressway network is not extensive, tolls do not account for a large share of total highway program revenues (Farrell 1999, 62–66).

Until the past decade, with few exceptions, toll roads were operated by public or quasi-public entities. However, Italy and Portugal privatized their major toll road providers through public stock offerings in 1999, and Spain sold some of its state toll road operators in 2003. France has begun to privatize its toll roads (*Toll Roads News* 2005).

TRENDS IN THE EVOLUTION OF THE FINANCE SYSTEM

Chapter 1 identified three arguments that have been used to motivate transportation finance reform. The first is that future oil price increases, advances in automotive technology, and new pollution and energy regulations will substantially reduce fuel tax revenues and thereby threaten the viability of the present finance system. The second is that the viability of the present system is threatened by an accumulation of structural changes that have caused it to diverge from the original concept of the user fee–trust fund system. The third is that, regardless of the stability of existing arrangements, reform presents opportunities for increasing the public benefits of transportation spending by improving operations of facilities and by directing funds to the best projects.

These lines of argument obviously are not mutually exclusive, and all three might be reasonable grounds for reform. This section examines the evidence supporting the second argument, which concerns the erosion of support for the user fee finance principle and the consequent decline in effectiveness of the present finance system. A premise of this argument is that the historical system, which reached its full development with the federal-aid highway act of 1956 and in the state programs with features parallel to the federal, served the public interest well. (Chapter 3 examines the evidence for this claim.) The basic features were that revenues derived from highway users were fully dedicated to paying for highway construction and operation and that these revenues covered all such costs other than

those for local streets. Trust funds were established to enforce the connection between user fee revenue and spending. The arrangement was perceived as fair by the taxpayers, generated revenues for a substantial highway program, and served efficiency to some extent since users recognized that any upgrading of highways required increases in fees.

However, according to this argument, in the evolution of transportation finance arrangements over the past 30 years, this original conception has been compromised:[1]

- Adherence to the user-pays finance principle has weakened as a result of devolution of responsibilities to local governments (which are less capable of collecting user fees and historically rely mainly on other revenue sources); diversion of highway user revenue to nonhighway purposes; resort to expedient sources of revenue in the face of pressing needs; and growing demands for transit improvements, which are unable to cover a major portion of their costs with fees.
- In part as a result of these changes in the structure of the program (which have tended to undermine the basis of its political support) but also on account of broader trends (the "taxpayer revolt" opposing growth in state and local government spending), the public and legislators no longer support fuel tax rates and fees necessary to sustain the programs, and the merit of the user-pays principle is no longer recognized.
- To the extent that the user fee finance system historically has had a positive effect on program performance, divergence from the principle has been harmful.

The subsections below describe developments in five areas of finance practices:

- Application of highway user fee revenue to nonhighway purposes and earmarking of federal aid,
- Legislative action to adjust user fees to keep up with inflation and cost changes,
- Devolution of responsibilities to local governments and related trends in reliance on user fee revenue,
- Revenue adequacy, and
- Revenue stability.

[1] For example, on decline in public or political support for user fee finance, see CTI 1996, Road User Fee Task Force 2003, and Giglio and Williams 2001; on conflicts with the user fee finance principle in recent trends in finance, see CBO 1998, 2–3; on growing local burdens and transit needs, see McMillan 2004 and Puentes 2004; on revenue diversions weakening the federal highway program, see Utt 2004 and Roth 2005.

Changes in these five areas of practice are indicators of the extent to which the finance system has departed from its original conception and its effectiveness as a funding mechanism has been altered.

Application of User Fee Revenue to Nonhighway Purposes and Earmarking of Federal Aid

As Chapter 1 noted, the practice of dedicating highway user revenues to purposes other than highways has been controversial. Highway program supporters sometimes have claimed that the accretion of diversions is a threat to the viability of the present finance system. Transit advocates and others argue that transit and the other uses to which highway-derived revenues have been dedicated are as reasonable applications of the revenue as is highway construction, and they object to the term "diversion" as implying that highway programs have a proprietary claim to the revenue.

Chapter 3 will present evidence that providing subsidies to transit and raising revenues from highway users that exceed the highway agency's cost of providing roads both can be justifiable practices, and that highway travelers benefit from transit's impact on highway congestion. However, regardless of the merit of arguments in favor of dedicating highway user revenues to transit or other nonhighway purposes, it is reasonable to suppose that the growth of such uses could affect the viability of the highway finance system by weakening its political support among highway users. Constituencies that might be expected to oppose nonhighway uses of revenues (or to cease to support maintaining highway user fees once such uses become large) include trucking companies and motorists who reside in nonmetropolitan areas.

Of $106.8 billion in highway user revenues collected in 2004 by the federal, state, and local governments, $10.7 billion was devoted to mass transit (either dedicated by law to transit, as the federal fuel tax revenues credited to the Mass Transit Account of the Highway Trust Fund, or allocated to transit at the discretion of local officials, for example, through the flexible fund provisions of the federal-aid highway program). In addition, $10.2 billion was credited to general funds or dedicated to purposes other than highways and transit. The share of state and locally collected highway user revenues that is devoted to purposes other than highways and transit grew from 10 percent in 1991 to 13 percent in 2004 (FHWA 1997, Table HF-210; FHWA 2005a, Table HF-10). As described above, the total spent on highways exceeds highway user fee revenue, primarily because local governments fund most of their street and road expenditures from general or non–user fee revenue sources. States also devote funds from nonhighway sources to highways. In national totals, states' revenues from highway users nearly equal their highway spending: the sum of all state-imposed highway user fee revenues and Federal Highway Trust Fund aid received by states was $94.7 billion in 2004

and current spending by states for highways plus state grants for highways to local governments was $95.3 billion (FHWA 2005a, Table HF-10). However, the balance between revenue and spending varies from state to state (FHWA 2005a, Tables DF, SF-1, SF-2).

The Federal-Aid Highway Act of 1956 created the Highway Trust Fund and dedicated to the fund all revenues from a set of excise taxes on highway fuels, vehicles, and parts, as well as an annual fee paid by operators of large trucks. Since 1983, a portion of the fuel tax (presently 2.86 cents per gallon) has been dedicated to mass transit. Since 1987, a small portion of the fuel tax (0.1 cents per gallon) has been devoted to the Leaking Underground Storage Tank Trust Fund. From 1990 until 2005, a portion of fuel taxes (2.5 cents per gallon from 1990 to 1993, 6.8 cents per gallon from 1993 to 1995, and 4.3 cents per gallon from 1995 to 1997 on all fuels, and 3.15 or 2.5 cents per gallon on gasohol only from 1997 to 2003) was credited to the general fund. The fraction of federal highway user revenues dedicated by federal law to nonhighway uses peaked at about 30 percent in the mid-1990s and has declined since (Figure 2-4).

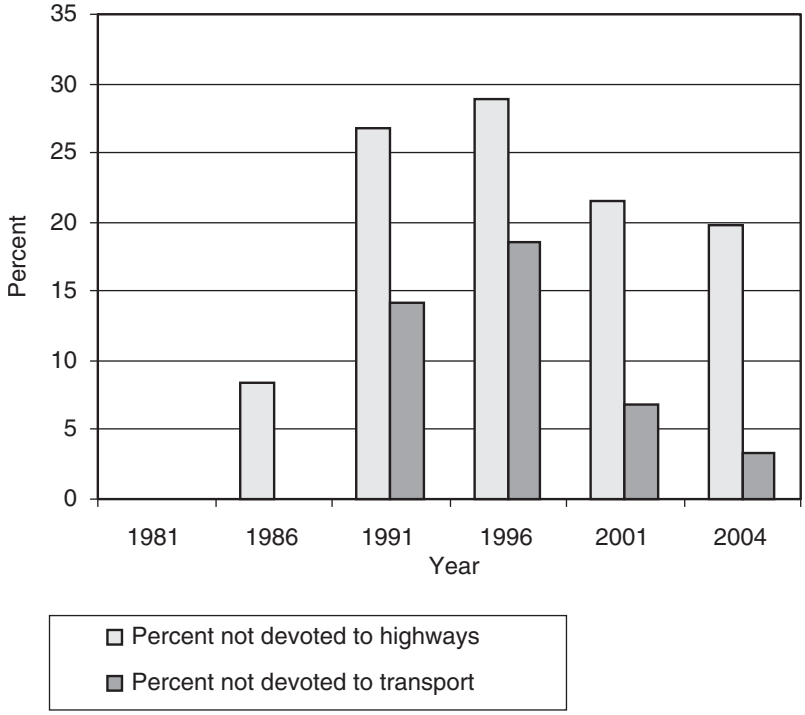

FIGURE 2-4 Percentage of federal highway user revenues not devoted to highways or transport, 1981–2004. (Sources: FHWA various years, Table HF-10.)

The preamble of the 1991 act reauthorizing the federal surface transportation aid program (ISTEA, the Intermodal Surface Transportation Efficiency Act) declared a new emphasis on intermodalism for the program: "It is the policy of the United States to develop a National Intermodal Transportation System [which shall consist of all forms of transportation in a unified, interconnected manner . . .]" (P.L. 102-240). ISTEA granted limited flexibility to state and local governments to use federal aid drawn from the Highway Trust Fund for transit and for nonhighway freight projects, and it increased the influence of local governments in project selection. Under the terms of two grant categories introduced in the 1991 act (the Surface Transportation Program and the Congestion Mitigation and Air Quality Program), states may choose to use grants for highway or nonhighway transportation purposes. These two categories constituted 24 percent of federal highway authorizations from 1998 through 2003. In 2004, states transferred $1.1 billion of federal-aid funds from highway programs to transit (FHWA 2005a, Table HF-10).

Out of $104.8 billion in spending at the state level for highways and transit in 2004 (including grants to local governments and to transit operators but excluding direct spending of independent transit operators owned by states), $9.5 billion, or 9 percent, was for transit. Highway user revenues dedicated to state transit programs or transit grants equaled less than half of this amount (FHWA 2005a, Tables MT-1A, MT-1B, HF-10, DF). Distribution of state highway user fee revenue for transit purposes is concentrated in a few states. In 2004, three states—New York, Pennsylvania, and Maryland—accounted for 58 percent of such distributions; 23 percent of highway user fee revenues collected by these three state governments was devoted to transit. In the remaining states, 3 percent of state highway user fee revenue was devoted to transit (FHWA 2005a, Table SDF). Although these shares of spending are disproportionate to relative use [1.8 percent of vehicular trips are by transit (Hu 2004, Table 7)], it is not evident that state transit spending is large enough nationwide to have a major impact on state highway programs.

The federal excise tax rate on gasohol (a blend of gasohol and ethanol) used as a highway fuel was lower than the rate on gasoline from 1979 through 2004. The data in Figure 2-4 reflect the crediting of part of gasohol tax revenue to the general fund, but not the lower tax rate. Taxing gasohol at the same rate as gasoline and depositing all revenues in the Highway Trust Fund would have increased trust fund deposits by about $1.6 billion (5 percent) in 2002. The General Accounting Office projected in 2002 that this forgone revenue would grow to $2.2 billion per year by 2012 if the present tax treatment of gasohol continued (Hecker 2002, 25). Legislation enacted in 2004 (the American Jobs Creation Act of 2004, P.L. 108-357) contained a provision setting the gasohol rate equal to the rate on gasoline and crediting all revenue from the tax to the Highway Trust Fund as of January 1, 2005. The gasohol subsidy via the

Highway Trust Fund was replaced with a subsidy representing a loss to the revenues of the general fund in the form of tax credits that gasohol producers earn for payment of the excise tax.

Congressional earmarking is a second practice affecting the use of federal-aid funds that has been the subject of controversy. A small but growing proportion of federal funding for highways is devoted to highway projects identified by Congress rather than to the normal grant programs. The latter provide funds, apportioned among the states according to formulas (taking into account population, traffic, and other state characteristics), that states and local governments can apply to projects that they select. If earmarking curtailed funding of the highest-value highway projects, then its financial impact on the highway program would be analogous to the impact of applying funds to nonhighway uses. Authorizations for projects specifically designated by Congress jumped from about 1 percent of the highway program in the 1982 and 1987 federal-aid highway acts to 5 to 6 percent in the 1991 and 1998 acts and to over 10 percent in the 2005 surface transportation aid program reauthorization legislation (SAFETEA-LU) (Table 2-8).

The impact of this practice depends on whether the projects Congress chooses have greater benefits than the projects that the states would choose if they received the funds through normal grants. To the extent that state and local governments have well-developed sources of information on project benefits and formal and open processes for setting priorities, there are grounds for concern that federal earmarking may divert some funds from higher-payoff to lower-payoff projects. State officials report that members of Congress sometimes solicit their state departments of transportation for nominations for projects for earmarking from among projects that are already in state capital plans and at

TABLE 2-8 Earmarked Projects in Federal-Aid Highway Acts

Act	Demonstration, Priority, or High-Priority Authorizations		Other Earmarks ($ billions)	Total Title I (Highways) Authorization ($ billions)	Percent of Authorization for Demonstration, High-Priority, or Other Earmarked Projects
	Amount ($ billions)	No. of Projects			
STAA, 1982	0.6	11	0.1	48.2	1.4
STURAA, 1987	1.0	152	0.1	67.1	1.6
ISTEA, 1991	6.2	539	1.0	120.8	6.0
TEA-21, 1998	9.4	1,850	1.4	171.1	6.3
SAFETEA-LU, 2005	14.8	5,700	6.3	199.5	10.6

NOTE: STAA = Surface Transportation Assistance Act; STURAA = Surface Transportation and Uniform Relocation Assistance Act; TEA-21 = Transportation Equity Act for the 21st Century.

SOURCES: HUF 1983; HUF 1987; USDOT 1991; USDOT 1998; FHWA 2005b.

advanced stages of preparation. These interactions may reduce the distorting effect of earmarking on project selection.

In contrast with some other federal infrastructure grant programs (in particular, the water resources development program) in which authorized projects frequently fail to receive appropriations of funds, in the federal-aid highway program all earmarked projects authorized to be funded from the Highway Trust Fund have federal funds available. Under the terms of the highway program, authorized amounts become available for obligation without further action by Congress. Apparently the majority of earmarked highway projects eventually are carried out, but many are not, in part because earmarked amounts often fall well short of project costs and projects do not correspond to states' priorities (GAO 1995, 25–26).

Although the fraction of federal funding that is earmarked for specific projects is growing, it remains small in the highway program compared with some other federal transportation programs. In the 5-year federal transit assistance program authorized in 2005 (SAFETEA-LU Title III), about three-quarters of grants to state and local governments are apportioned by formula and one-quarter are earmarked or discretionary (FTA 2005). Substantial amounts of discretionary funds are earmarked. Most inland waterways and ports authorizations are for specifically identified projects.

Legislative Adjustments of User Fee Rates

Because fuel tax rates are defined in cents per gallon, state and federal legislative action is required to adjust for the effects of inflation on revenues. In contrast, sales taxes or income taxes automatically generate higher revenues in nominal dollars as prices and wages rise. This dependence on regular legislative action, coupled with allegedly increasing political resistance over time to tax rate increases in general, is commonly cited as a principal disadvantage of reliance on the fuel tax as the main revenue source for transportation programs. For example, a background paper for the Transportation Research Board's 2000 National Finance Conference cited "political barriers to raising user taxes" as one of the "fundamental structural problems" of the current highway finance system and observed:

> Fuel taxes are regarded as just another tax, and politicians risk losing their jobs if they raise fuel taxes to meet the full costs of the highway system. . . . [I]ncreases in user fees have been few and far between. During the 1980s, states raised their own fees to match inflation on a regular basis. . . . By the 1990s, the number of states increasing their gas tax had dropped. . . . Federal taxes dedicated to transportation had not been raised since the famous nickel increase in 1982 until the enactment of TEA-21. (Giglio and Williams 2001, 199–200)

Similarly, the California and Oregon transportation finance studies summarized in Chapter 1 both assume that future substantial increases in fuel tax rates will not be a feasible solution to funding problems.

It has been argued that legislatures' failure to adjust fuel tax rates arises not simply from inattention, unpopularity of taxes in general, or competition from other programs for resources, but from an inherent structural flaw of the fuel tax. The Federal Highway Administrator expressed this view as follows (Peters 2004):

> In the 1950s and '60s, when the interstate system was built, a gas tax made sense because virtually every driver benefited from a new, nationwide highway system. But today, capacity and maintenance are largely urban and suburban problems unique to the short lengths of highway used by commuters. Raising gas taxes does little or nothing to improve commuter congestion and punishes the millions of drivers and businesses that don't use busy urban highways.

In other words, according to this argument, needs are concentrated (on urban roads and transit, and primarily in a small number of highly congested urban areas) but the revenue source is broadly based, so many voters oppose tax increases because they see the benefits going elsewhere. This argument finds support in reports of recent state transportation finance debates indicating that rural and small-town legislators perceive that their constituents tend to drive a lot and hence pay high taxes, while pressures to increase spending are strongest in urban areas (Montgomery 2004; Barnes 2005).

As the first section of this chapter described, in spite of these potential obstacles to maintaining highway user fee revenue, the average constant-dollar user fee paid per vehicle mile of highway travel has been fairly constant since the late 1970s. The average state gasoline tax rate also shows no consistent trend over this period (Figure 2-5). The rate is higher today than during the 1980s, although it has declined in the past decade. The frequency of revisions of state gasoline tax rates has slowed. About four states per year changed the rate in the past decade compared with eight per year in the 1980s (Figure 2-6), but the decline may be attributable, at least in part, to the slowing of inflation during the period. At the end of 2004, gasoline excise tax rates in 23 states were the same as or lower than the rates in 1994, although the rates in 11 of the 23 states remained above the national average of $0.191 per gallon. Only five states had rates below $0.15 per gallon (FHWA 2005a, Table MF-205).

Not all states depend on legislative action to change rates. At least nine states (Florida, Iowa, Kentucky, Maine, Nebraska, New York, North Carolina, West Virginia, and Wisconsin) have variable rate cents-per-gallon gasoline taxes. In five of these states (Florida, Nebraska, New York, North Carolina, and Wisconsin), the tax rate was adjusted nearly every year from 1998 to 2004 without legislative action (FHWA 2003, Table MF-121T; ARTBA 2004; *AASHTO Journal* 2005). Methods of indexation vary, and the effects on revenue have sometimes not been

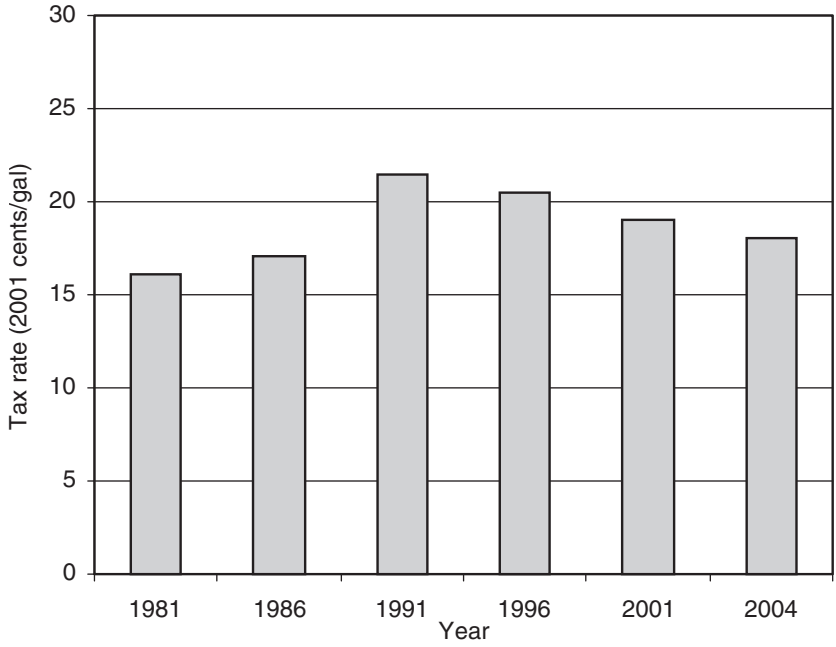

FIGURE 2-5 Sales-weighted constant-dollar average state gasoline tax rate, 1981–2004. (Sources: FHWA 1987; FHWA 1997; FHWA 2005a, Table MF-205.) Price index is gross domestic product implicit price deflator (BEA 2002, 135; BEA 2005, 188–189).

those intended (Ang-Olson et al. 2000). (See Chapter 6.) Wisconsin has repealed its automatic adjustment after 2006. Several states collect sales taxes on highway motor fuels, although revenues from these taxes are generally not dedicated to highway use.

In assessing the willingness of state legislatures to adjust highway user taxes, it is instructive to compare overall state government tax effort with highway user fee revenues. In the 1960s and 1970s, revenue from all state taxes grew much faster than state highway user fee revenue (Figure 2-7). In the 1980s and 1990s the difference lessened, although in recent years total state tax revenues have continued to grow faster than highway-related revenues. In the period shown in Figure 2-7, the sphere of state government responsibilities was expanding. Consequently, highways' share of state government total expenditures (including transfers to local governments) fell from 23 percent in 1960 to 15 percent in 1970 and 7 percent in 2002 (U.S. Census Bureau 2005b, Table 438; U.S. Census Bureau 1976, Table 439).

The history of changes in the rate of the federal excise tax on gasoline since the 1956 federal-aid highway act is as follows:

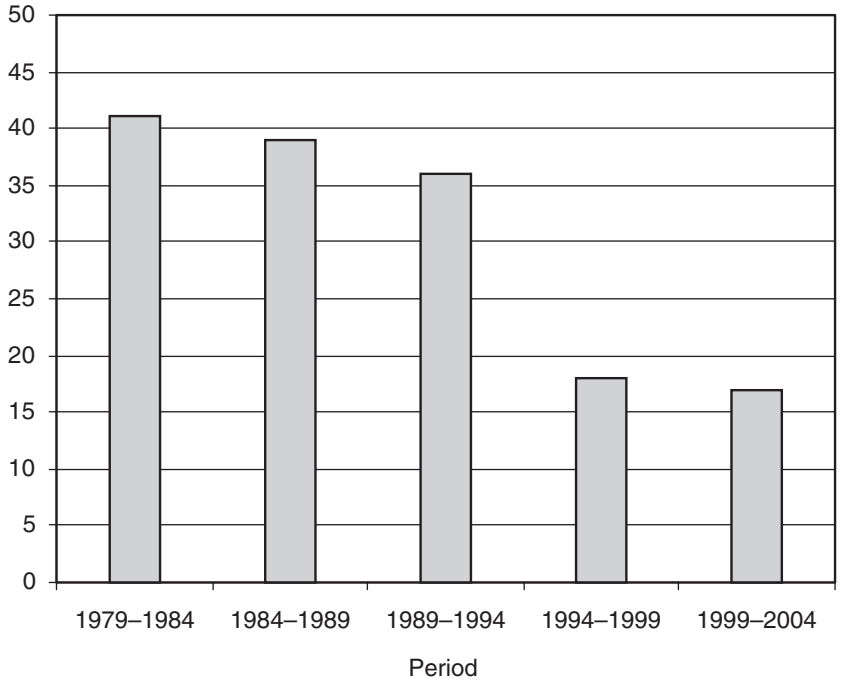

FIGURE 2-6 Number of states raising cents per gallon gasoline tax rates, 5-year intervals, 1979–2004. Note: Eleven states lowered rates during some interval in the period 1979–2004. (Sources: FHWA 1987; FHWA 1997; FHWA 2005a, Table MF-205.)

Year	Rate ($/gallon)
1956	0.03
1959	0.04
1983	0.09
1987	0.091
1993	0.184
1996	0.183
1997	0.184

In constant dollars, the rate today is about 7 percent higher than in 1956. The diesel fuel rate increased from $0.03 per gallon in 1956 to $0.244 per gallon since 1997. The rates for the excise tax on sales of new large trucks and trailers and the heavy vehicle use tax (an annual federal fee for all large trucks in use) were last increased in 1984 (FHWA 1997, Tables FE-101a, FE-101b; FHWA 2003, Table FE-21B). Changes in law in 1997 (when $0.043 per gallon that had been credited to the general fund began to be credited to the trust fund) and in

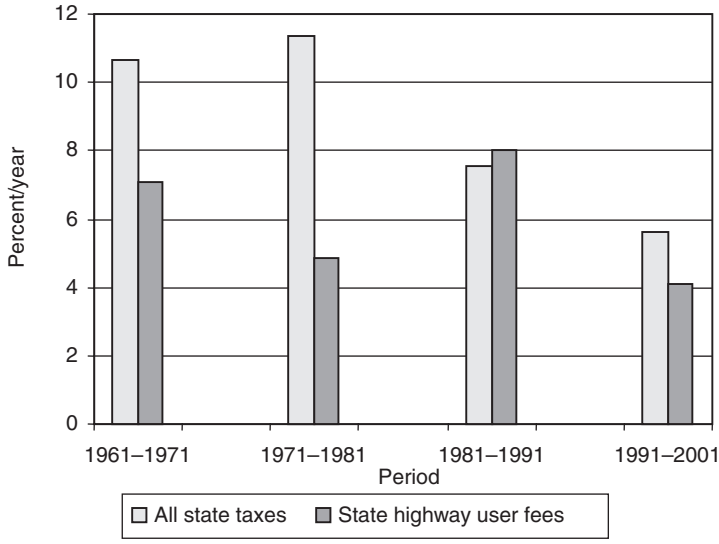

FIGURE 2-7 Average annual percentage growth rates, all state tax receipts and state highway user fee receipts, 10-year periods, 1961–2001. (Sources: FHWA various years, Table MF-121T; Baker 2003.)

2004 (when the revenue impact of the federal gasohol subsidy was transferred from the trust fund to the general fund) increased contributions to the Federal Highway Trust Fund without increasing the fuel tax rate paid by motorists.

Devolution and Reliance on User Fees

As Chapter 1 described, parallel trends in at least some jurisdictions toward devolution of responsibilities for transportation programs from state to local government (that is, municipalities, counties, and special authorities districts within a state) and decreasing reliance on user fees have been cited as threats to the continuation of historical highway finance arrangements. Whereas state government highway programs are predominantly funded by state-imposed user fees (fuel taxes and registration and licensing fees) and federal aid derived from federal user fees, local governments historically have relied mainly on property and sales taxes to pay for transportation programs. Therefore, devolution of transportation program responsibility to local government would be likely to entail decreased reliance on revenues from fuel taxes, registration fees, and tolls.

Devolution of responsibilities to local governments would in many circumstances be in the public interest, if it were accompanied by adequate finance arrangements. When local governments provide facilities and services whose primary users are local residents, taxpayers are most likely to receive the kinds of

services they want and are willing to pay for. However, devolution of transportation programs may lead to finance and governance problems if revenue sources remain oriented toward state-level programs.

One popular way to fund expanded local transportation responsibilities has been adoption of new special taxes, with revenues dedicated for a specified term to a specified set of projects. Such taxes often require approval in statewide or local referenda. A study by the Surface Transportation Policy Project identified 41 such referenda on ballots in 2002: nine at the state level that would have authorized $77 billion of spending and 32 local referenda for $40 billion. (Not all were approved.) Most revenues were to be derived from dedicated taxes other than user fees. Such special taxes typically fund both transit and road projects. The growth in local dedicated taxes has been driven in part by growing local expenditures on transit and the absence of secure funding sources for transit analogous to the state and federal highway user fees dedicated to highways (Ernst et al. 2002, Goldman and Wachs 2003, McMillan 2004).

Nationwide, for highways only, the local government share of spending has averaged around 35 percent since the 1960s and shows no consistent trend (Figure 2-8). The ratio of highway user fee revenues to highway expenditures over the same period also shows no trend (Figures 2-9 and 2-10). Local governments

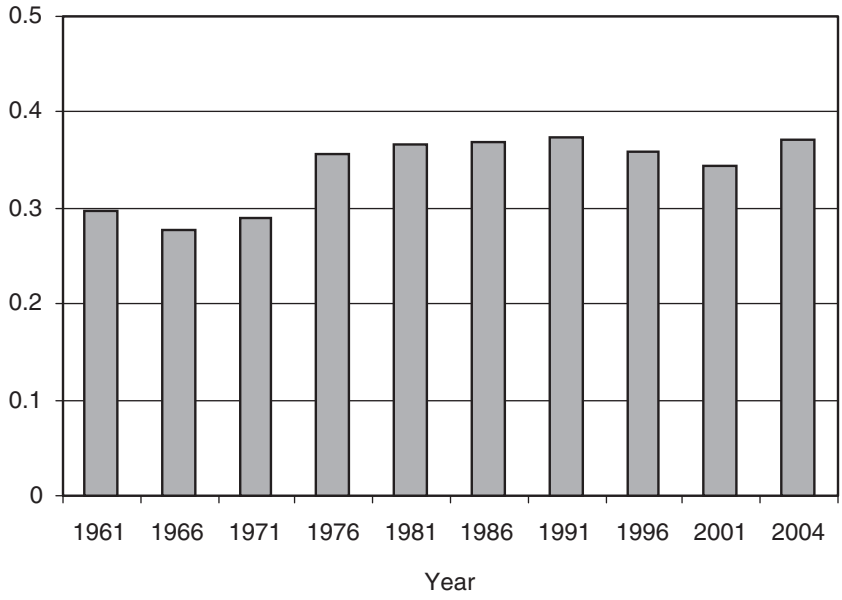

FIGURE 2-8 Ratio of local government highway, road, and street expenditures to total U.S. highway, road, and street expenditures, 1961–2004. (Sources: FHWA various years, Table HF-10.)

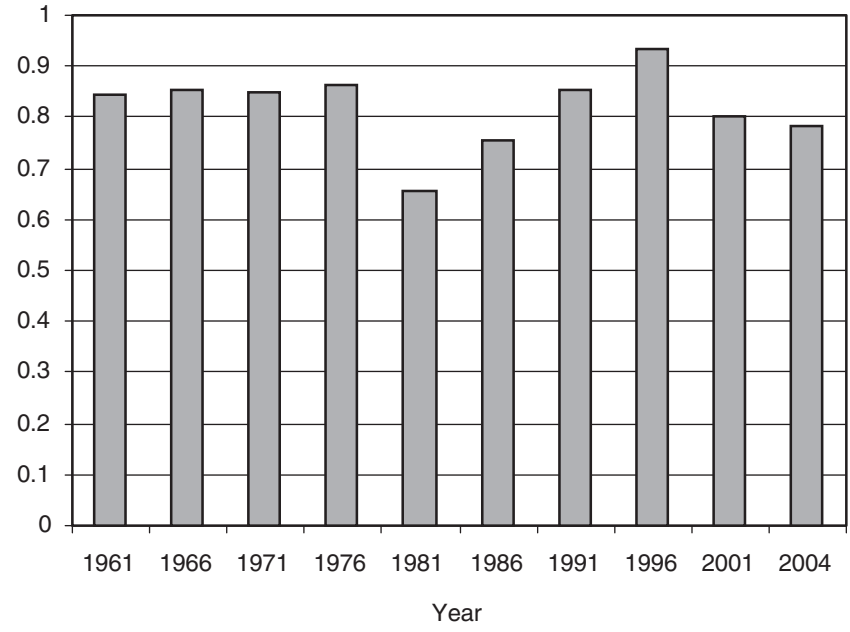

FIGURE 2-9 Ratio of highway user fee revenues to highway expenditures, 1961–2004. (Sources: FHWA various years, Table HF-10; FHWA 1997, Table HF-210.)

account for most spending not supported by user fee revenues. In 2004, local user fee revenue plus local highway grant receipts that derived from state and federal highway user fees equaled 32 percent of local highway spending (FHWA 2005a, Table HF-10). As a percentage of local spending, local user fee revenue plus grants from states has been declining slowly since the 1970s.

Local governments' lack of reliance on user fees is the result of historical and practical circumstances. Local jurisdictions may lack legal authority to impose fuel taxes or vehicle fees, and motorists can easily avoid a local fuel tax if neighboring jurisdictions have lower rates. In general, fiscal competition among local governments makes them more susceptible than state governments to loss of a tax base when they try to increase revenue by increasing tax rates independently. In some instances, a local property tax assessment dedicated to streets or infrastructure may function essentially as a user fee—for example, in a suburban residential community where the streets to be maintained are primarily for local access, there is little through traffic, and household characteristics are somewhat uniform. Such taxes may be an entirely satisfactory means of paying for local streets, since replacing them with a fuel tax or a mileage fee might have negligible effects on street use or expenditures.

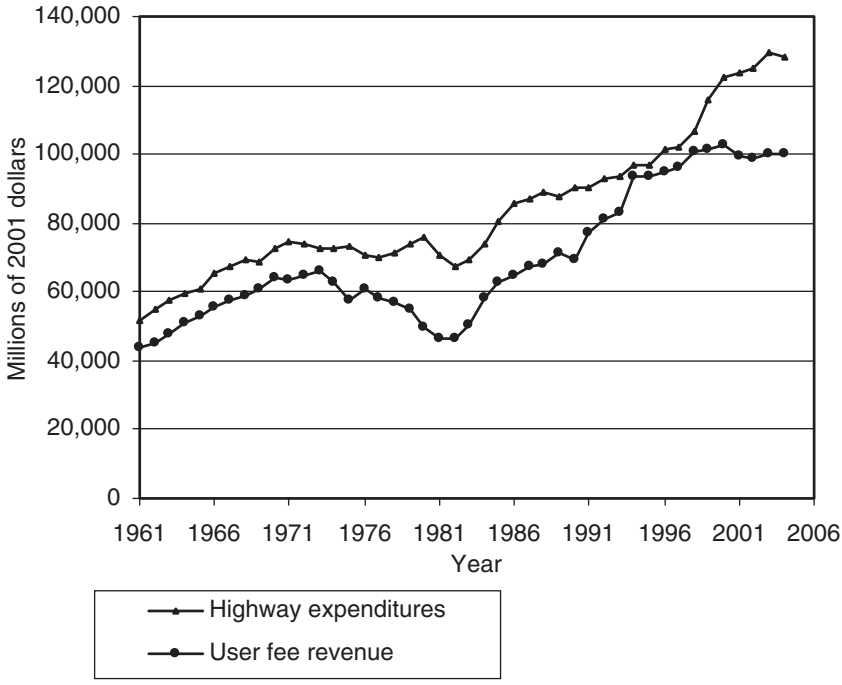

FIGURE 2-10 Highway user fee revenue and highway expenditures, 1961–2004. (Sources: FHWA various years, Tables HF-10, FE-10a.) Price index is gross domestic product implicit price deflator (BEA 2002, 135; BEA 2005, 188–189).

National totals obscure substantial state-to-state variation in relative local government shares and in the trend in state and local shares. Comparison of local government shares of transit plus highway spending in 1991 and 2002 in the United States and in the six states with the most spending illustrate the variation (Table 2-9).

As the two lines labeled "United States" in the table indicate, in 2002 state governments nationwide retained responsibility for 62 percent of highway spending (100 percent minus the 38 percent local share) and 51 percent of total highway and transit spending. In the United States as a whole and in five of the six states shown (all except Illinois), the local share of highway spending fell over the decade. For the total of highway and transit spending, the local share rose slightly nationwide (from 47 to 49 percent) and in three of the six states (California, Illinois, and Texas).

The magnitude of local government transportation responsibilities has led to calls for greater direct local control of revenue. For example, a 2004 paper published by the Brookings Institution (Puentes 2004), arguing for increased direct

TABLE 2-9 Total Spending and Local Shares for Highways and All Transportation, United States and Selected States, 1991 and 2002

	1991		2002	
	$ billions	Percent Local	$ billions	Percent Local
State and local spending, highways				
United States	72	39	124	38
California	8	50	12	48
Florida	3	45	7	37
Illinois	3	34	6	46
New York	5	59	9	50
Pennsylvania	3	33	6	24
Texas	5	41	9	38
State and local spending, highways plus transit				
United States	88	47	157	49
California	10	59	18	63
Florida	3	51	8	45
Illinois	5	53	8	60
New York	10	77	18	75
Pennsylvania	4	34	7	34
Texas	5	45	11	48

NOTE: Amounts include capital and operating expenditures and exclude debt service. Local transit spending includes all transit spending except direct state mass transit activities as defined in FHWA 2004, Table MT-1A. Direct state mass transit spending for 1991 is estimated. Local highway spending includes expenditure of grant funds received from states.

SOURCES: FHWA 1992, FHWA 1993, FHWA 1994, FHWA 2003, FHWA 2004; Tables HF-2, LGF-2, SF-2, MT-1A, MT-2A, MT-2B.

local government control of federal grants, observes: "Metropolitan areas make decisions that dispose of only about 10 cents of every transportation dollar they generate even though local governments within metropolitan areas own and maintain the vast majority of the transportation infrastructure." However, considering only highways, state governments in 2003 owned and operated roads that carried 64 percent of all vehicle miles of travel, and state government direct spending on highways was 64 percent of all highway spending (FHWA 2004, Tables HM-81, VM-1, HF-10). Thus by this measure at least, state and local resources may appear, on average, to be in line with state and local infrastructure responsibilities. As Table 2-2 shows, state governments collect nearly all nonfederal highway user revenues, but a third of these revenues are devoted by the states to local government grants or other local purposes (FHWA 2005a, Table DF). It is only when the state and local shares of transportation-generated revenue

(mainly derived from highways) are compared with their shares of total highway and transit spending that an apparent imbalance emerges.

In summary, when nationwide aggregates of highway spending and highway user-derived revenues are examined, neither devolution of responsibility to local governments nor decline in the ratio of user revenue to expenditures is evident. However, there may be a trend toward devolution of responsibility for the total of transit and highway spending in some states.

Revenue Adequacy

To many critics of the present finance system, the culmination of its structural flaws has been failure to generate sufficient revenues to keep up with growth in traffic and to replace aging facilities. Illustrating this view are two comments, the first by a Senate Environment and Public Works Committee staff member and the second by the president of the Motor Freight Carriers Association: "There's a growing recognition that we need to begin to move to new approaches for financing. . . . The pay-as-you-go user fee that we've had in place since 1956 is not really up to the task" (McNally 2004) and "The inability of Congress to tax or not to tax, to toll or not to toll, makes it impossible to pay for a core program" (Wlazlowski 2004). The *AASHTO Journal* (2004) reports the conclusion of the Federal Highway Administrator in an address that the current fuel-tax-based system of financing highways is likely to fall short of covering identified needs, and a Brookings Institution study of fuel tax revenues concludes that because of stagnant revenues, "states do not have the financial wherewithal to address a wide variety of transportation concerns" (Puentes and Prince 2003). To clarify the basis for these concerns, this section describes aggregate trends in highway spending and highway system expansion compared with highway use, and contrasts these trends with experience in other industries.

As Chapter 1 explained, the committee did not interpret its task as finding revenue mechanisms that will support an increased level of spending for transportation. However, if the present funding arrangement has structural features that are causing its effectiveness as a means of raising revenue to decline, its viability would be questionable.

From the late 1940s to the 1960s, constant-dollar capital expenditures for highways grew at least as fast as did highway travel; since that time, while annual vehicle miles have steadily grown, the long-run trend in real capital expenditures appears nearly flat (Figure 2-11). This trend has been interpreted as evidence of chronic revenue inadequacy (e.g., CTI 1996, 16–17; Consdorf 2003). However, a constant rate of capital expenditures can yield growth in capacity if assets are long-lived. Economic measures of the capital stock of highways have been developed by the Bureau of Economic Analysis (BEA) (Katz and Herman 1997) and FHWA (Fraumeni 1999). The measures are derived from data on all past capital

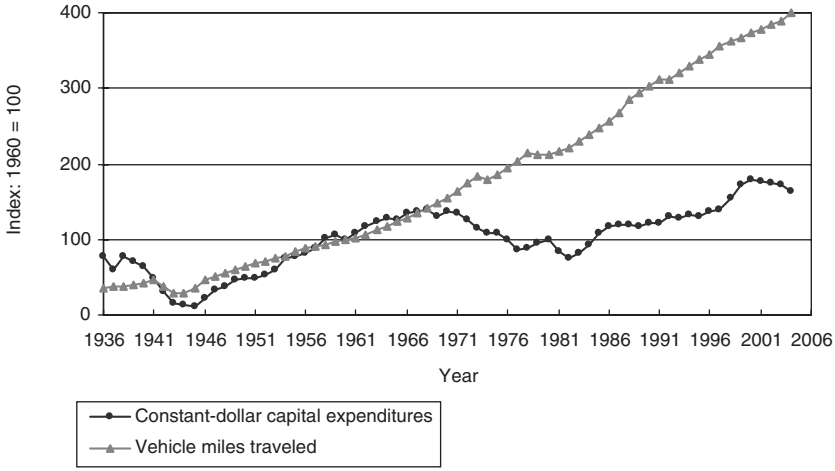

FIGURE 2-11 Highway capital expenditures and vehicle miles traveled, 1936–2004. (Sources: FHWA various years, Tables HF-10, VM-1.) Price index is private nonresidential structures (BEA 2005, 188–189).

expenditures on streets and highways by all levels of government (expressed in constant dollars) and estimates of rates of depreciation (or of decline in productive capacity). The measures are intended as indices of capacity, in which different kinds of facilities are aggregated by weighting them according to the relative costs of providing them.

The measures from both these sources indicate that the stock of highways is growing. The BEA measure shows an average annual growth rate of 2.1 percent for capital stock between 1985 and 1995. The average annual growth rate for vehicle miles in the same period was 3.2 percent. The FHWA measure, which uses a definition somewhat different from BEA's, indicates that net capital stock (defined as the sum of all past investment, less retirements, adjusted for efficiency decline of the stock as it ages) grew at an annual rate of 1.7 percent from 1985 to 1995, 1.3 percent from 1975 to 1985, and 5.1 percent from 1955 to 1975 (Figure 2-12). Much highway capital expenditure today—for example, projects to widen lanes, improve roadway geometry, or improve traffic control—increases capacity but is not reflected in gross indicators of physical capacity like road miles.

A Transportation Research Board study of freight transportation capacity (TRB 2003, 54–55) pointed out that the pattern of an increasing ratio of output to infrastructure capital is not unusual in U.S. industry. The ratio of output to net capital stock of structures has been rising in the railroad industry, and another network industry, electric utilities, shows a similar trend. In the rail and electric utility industries, these trends are interpreted as productivity growth. Changes in ratios of output to infrastructure capital in the three industries from 1959 to 1995

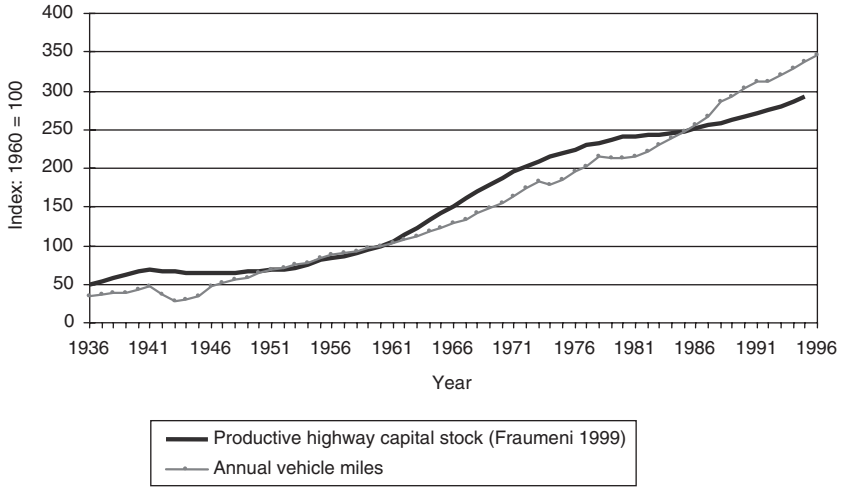

FIGURE 2-12 Net capital stock of highways and streets; annual vehicle miles, 1936–1996. (Sources: FHWA various years; Fraumeni 1999.)

were as follows (Fraumeni 1999; Katz and Herman 1997; EIA 2002, Table 8.5; Wilson 2001):

Industry and Ratio	Change (%)
Highways [annual VMT/(productive capital stock)]	+16
Railroads [annual ton-miles/(structures net capital stock)]	+360
Electric utilities [annual electric energy consumption/(utility net capital stock)]	+200

This comparison suggests that relatively lackluster productivity growth in the highway industry may merit concern. Highway productivity could be increased by concentrating investment in the most valuable projects; improving traffic management through better engineering or through pricing; and adopting more cost-effective design, construction, and maintenance practices.

Trends in spending, investment, and capital stock relative to traffic volume are useful as indicators of changes in underlying economic and political factors that drive transportation system development but cannot by themselves provide guidance on appropriate levels of spending. An investment rule that called for increasing capital spending, capital stock, or lane miles of roads at the rate of increase of traffic would yield poor results, since such a rule would fail to take into account the circumstances that determine the return on highway investment. These circumstances include the capacity and condition of the highway system at the outset of the period under consideration (e.g., whether it was over- or underbuilt), the possibility of economies of scale as the system expands, technological progress and

improvements in operating practices that allow growth in the productivity of infrastructure, and rising costs of providing infrastructure. As the cost of incremental expansion of capacity increases, providing levels of service that were considered normal in the past may lose economic justification. Chapter 3 will examine the available evidence on whether highway investments that would yield worthwhile benefits are not being made for lack of funds.

Revenue Stability

The transportation finance system has also been charged with failure to provide stable funding, because revenues depend on unpredictable external events like petroleum market developments and automotive fuel economy trends (Giglio and Williams 2001, 200). A more common view may be that stability and predictability are among the strengths of the user fee–trust fund mechanism compared with funding dependent on annual legislative appropriations, even though lags between changes in the external factors affecting fuel tax revenue and legislative adjustments of rates have at times disrupted funding. Constant-dollar highway capital spending declined severely from the mid-1970s through the early 1980s but recovered later (Figure 2-11). The same trough is evident in trends in the rate of growth of capital stock (Figure 2-12), in constant-dollar highway user revenues and the ratio of revenues to spending (Table 2-3), and in the average highway user fee per mile (Figure 2-1). These disturbances resulted from the impact of high inflation on constant-dollar fuel tax revenue, rising motor vehicle fuel efficiency driven by fuel economy regulations and fuel prices, and slower growth in driving as a result of higher costs and economic recession. State legislatures and Congress eventually responded with increases in nominal tax rates (Figure 2-6). Reducing the risk of unintended funding disruptions in the future might be a worthwhile goal of reforms to the transportation finance system.

REFERENCES

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transit Association *and* American Public Transportation Association
ARTBA	American Road and Transportation Builders Association
BEA	Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
CBO	Congressional Budget Office
CTI	Commission on Transportation Investment (California)

EIA	Energy Information Administration
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GAO	General Accounting Office
HUF	Highway Users Federation
IWR	Institute for Water Resources
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

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Evaluating the Present Finance System

This chapter is a summary of evidence relevant to evaluating existing highway and transit finance arrangements. Chapter 1 observed that the finance system ought to be judged on the basis of its effect on the performance of the transportation system. The measure of performance is the benefits derived from highways and transit in return for their costs. The elements of the finance system are the fees users pay, sources of funds, and the rules and practices that govern spending decisions. Each of these elements influences performance. User fees influence whether facilities are used efficiently because they discourage trips that travelers value little in comparison with the cost of providing them. Also, the revenue available from user fees and other sources is a constraint on decisions to build and upgrade facilities. If existing facilities are inefficiently operated (that is, if they are producing net benefits that are less than they could produce with better management or pricing), if capital spending is not being reliably directed to high-payoff projects, or if low-payoff projects are receiving funds, then the finance system is not giving travelers and transportation agencies the feedback that a well-designed system could provide to guide decisions.

As Chapter 1 also described, in political discussions the transportation finance problem is defined primarily as a problem of revenue adequacy, and proposals for new finance arrangements commonly take the form of packages of revenue enhancements designed to meet a target.[1] The effect of finance on performance

[1]For example, a 2004 state revenue proposal was reported as follows: "[The governor] proposed raising nearly $250 million for transportation projects throughout the state . . . by increasing fees and fines on speeders, drunk drivers and anyone who owns a car. Under the plan, . . . vehicle registration fees would jump from $81 to $128 every two years for most cars and from $108 to $180 for larger cars and SUVs. Moving violations would carry a $50 surcharge. . . . And a conviction for drunken driving would come with . . . an extra $200 fee. The plan would also dedicate taxes on rental cars entirely to transportation projects. . . . Together with previously announced plans to increase driver's license fees

usually has not received explicit consideration. Public officials have, however, generally respected certain historical principles in developing finance arrangements. These include the practice of user fee finance (motorists pay special taxes according to their use of roads, and revenue from these taxes covers highway spending); trust funds to keep track of the balance between fee revenue and spending; cost allocation rules that dictate higher charges for heavy than for light vehicles; and a division of revenue-raising responsibility and spending authority among the federal, state, and local governments. The question this chapter addresses is whether the principles that public officials rely on have led to finance arrangements that promote good performance.

Alternative sets of principles for transportation finance are in use or have been proposed. Other U.S. transportation modes follow different practices with respect to reliance on user fees and federal involvement in funding (see Table 2-6 in Chapter 2). It is probable that the performance of these modes would be greatly altered if they were to adopt finance systems more similar to the one used for highways. In most other countries, no connection exists between highway spending and the revenues generated by fuel taxes and vehicle fees, and it has been proposed that the United States follow the more common practice internationally in this regard. Finally, proposals for expanded use of tolling and for road use metering and charging, which will be examined in Chapter 5, represent fundamentally different finance practices.

A confident evaluation of the effect of present finance arrangements on performance is not possible with available information. Transportation agencies seldom conduct economic evaluations of their operations or of completed capital projects (GAO 2005). There have been few analyses of how changes in the structure of highway user fees changed users' behavior or of how the practice of trust fund finance in highways or other modes has influenced total spending and project selection. Therefore, only fragmentary evidence can be cited in this chapter, and conclusions are tentative. Better information derived from systematic evaluations of finance practices will be necessary to guide successful policy reforms.

The first section below reviews criteria that have been applied for evaluating revenue sources for government-owned highways and transit. The next two sections review evaluations of the overall performance of the U.S. highway and transit industries from the standpoint of economic efficiency—that is, whether the level of spending is justified, whether capital spending has been directed toward the projects with the best returns, and whether existing capacity is efficiently

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and collect more taxes from corporations, the proposal would pump an additional $266 million into the transportation trust fund" (Montgomery 2004). This perspective also was expressed in congressional testimony by the Executive Director of the American Association of State Highway and Transportation Officials (AASHTO) on the federal-aid program: "needs continue—by anyone's measures—to far outstrip available . . . resources. . . . AASHTO is seeking a substantial increase in funding . . . for both highway and transit programs. . . . The challenge is how to fashion a funding solution that can achieve these goals and garner the bipartisan support needed for enactment" (Horsley 2002).

managed. These evaluations provide evidence on whether the institutions and practices that govern finance have tended to promote prudent spending.

The fourth section examines how certain features of the existing finance system, including user fees, the practice of dedicating revenues from users to specified purposes, and the federal structure of the system, may affect government transportation programs. These features are relevant because they influence the cost-effectiveness of spending today and because they would require revision if new funding sources are introduced.

CRITERIA FOR EVALUATING FUNDING SOURCES

A standard set of criteria has evolved in past evaluations of tax alternatives and sources of funds for public infrastructure programs. Box 3-1 shows criteria from two sources, the Oregon Road User Fee Task Force study described in Chapter 1 and a study of funding alternatives prepared for the state departments of transportation through the National Cooperative Highway Research Program (NCHRP). The criteria proposed in the NCHRP study were derived from a review of about a dozen tax studies carried out by state governments mainly in the 1980s. The criteria in all the studies involve revenue adequacy, administrative feasibility or cost, and some fairness or equity concept. All the studies seem to accept as a premise that a dedicated revenue source is sought; that is, that transportation expenditures are to be funded by revenue from identified taxes or fees.

These lists together contain all the relevant considerations, but definition and application of some of the criteria have been difficult. Equity or fairness is given diverse and sometimes subjective definitions. As noted in Chapter 1, the concept of efficiency often is vaguely defined or missing. (It is missing from the Oregon study's list, even though the study recommends congestion pricing.) Few if any of the original studies attempt to quantify efficiency impacts of alternative transportation tax or fee schemes.

The difficulty that governments have experienced in defining measures of fairness and efficiency that provide useful direction on highway funding is illustrated by the highway cost allocation studies. These studies have been conducted periodically since at least the 1950s by the federal government and by many states to determine the relative taxes or fees that should be charged to different classes of vehicles—in particular, to large trucks. To establish criteria for evaluating the federal highway user fee schedule, the federal studies have sought to follow the declaration of policy in the 1956 highway act, which created the Federal Highway Trust Fund: "if it hereinafter appears . . . that the distribution of the tax burden among the various classes of persons using the Federal-aid highways, or otherwise deriving benefits from such highways, is not equitable, the Congress shall enact legislation in order to bring about . . . such equitable distribution" (Highway Revenue Act of 1956, P.L. 627, June 29, 1956, Section 209). The federal study authors

BOX 3-1

Examples of Criteria Used to Evaluate Highway Funding Alternatives

Oregon Road User Fee Task Force (Whitty 2003, 23)
(The task force was charged by the legislature with designing new revenue sources to support Oregon roads and replace the existing sources.)

Criteria for new revenue sources:

- Any new revenue system should be founded on the principle that users pay.
- Revenue sources traditionally the province of local government should not be usurped by the state.
- New sources should generate sufficient revenue to replace the fuel tax.
- Financing should be transparent: fees should be visible to payers and the public should know how much they are paying and how rates are calculated.
- The costs of collection and of payers' record keeping should not be substantial financial burdens.
- Revenue collection must be enforceable.
- The new system must support all roads of the state and local governments.
- Any new revenue source should be acceptable to the public.

NCHRP Report 377: Alternatives to Motor Fuel Taxes for Financing Surface Transportation Improvements (Reno and Stowers 1995, 49–51)

Criteria for evaluating tax alternatives (derived from a review of tax studies produced by 13 states):

- Adequacy:
  - Yield in relation to need, uses, investment requirements
  - Responsiveness to inflation
  - Stability of revenues over time
  - Potential for needed increases
- Equity:
  - With respect to costs occasioned
  - With respect to ability to pay and benefits received
  - By geographic area
  - In perception as well as in fact

(*continued on next page*)

BOX 3-1 (*continued*)
Examples of Criteria Used to Evaluate Highway Funding Alternatives

- Efficiency:
  - Bringing about better decisions on travel and investments
  - Paying costs imposed on others
  - Creating disincentives for undesirable activities
  - Enabling economic growth
- Simplicity:
  - Administrative cost
  - Compliance cost
  - Enforcement cost
  - Evasion potential

have interpreted this declaration to require that the share of fee revenue generated by each of a number of vehicle classes (i.e., cars in each of several size classes and trucks in classes defined by size and axle configuration) should equal the share of government expenditures attributable to each class's use of the highways. The federal studies acknowledge efficiency as an ideal criterion but do not apply it to discriminate among tax alternatives[2] (USDOT 1997, VI-22–VI-29).

Past Transportation Research Board (TRB) committees noted that the missing analysis in the highway cost allocation studies is an evaluation of how adjustments in the structure of user fees would affect the economic benefits derived from the highway system. A TRB committee studying the social costs of transportation advised that "practical constraints on user fee policies—revenue requirements and considerations of administrative and political feasibility—do not preclude promoting efficiency through user fees. . . . For any two fee options under comparison, . . . one will encourage economically beneficial use of the facility more than the other. These differences ought to be weighed carefully in decisions on tax policy" (TRB 1996, 126–128). A committee on cost allocation offered step-by-step guidelines for analyzing the effects of changes in user fees on highway performance and benefits (Committee for the Review of the Federal Highway Cost Allocation Study 1996, 4–6).

[2]The 1997 federal study contains comparisons of estimates of marginal costs of highway travel (including congestion costs) with user fees. This approach to assessing whether fees promote efficiency is insufficient because it provides no basis for judging whether the correspondence between fees and costs is "close enough." The NCHRP study cites discussions of efficiency in the state transportation funding studies, but no example of a study that used efficiency as a quantitative criterion for comparing alternatives (Reno and Stowers 1995, 103–110).

The elements of a comparison of user fee alternatives on the basis of their effect on the benefits derived from highways are illustrated in the Brookings Institution study of road user charges, *Road Work.* The study compared the savings from charging trucks for pavement wear through an ideal pricing scheme with savings if a simplified tax schedule were applied (Small et al. 1989, 71–74). The ideal pricing case assumes that each large truck is charged a fee per mile that depends on the number and spacing of the truck's axles, the load on each axle, and the road that the truck is traveling on. The fee would equal an estimate of the actual increment in the highway agency's pavement maintenance cost caused by each trip of the truck on the road. The charge would depend on the road because the wear a truck causes depends on pavement thickness and other roadway characteristics.

In the simplified fee case, each truck is charged a fee per mile that depends on its axle configuration and axle loads but is the same for all roads and is set so as to maximize the highway agency's savings, less the added costs to shippers and carriers (not counting fee payments). In both cases, it is assumed that the highway agency designs pavements to minimize the sum of vehicle operating costs and agency construction and maintenance costs. The following are the study's estimates of changes in highway agency pavement costs and in shipper and carrier costs if such charges were imposed, compared with costs if actual user fees were continued (Small et al. 1989, Tables 4-2, 4-4) (figures are in billions of 1982 dollars):

Item	Ideal Pricing	Simplified Fees
Change in highway agency pavement costs	–2.1	–1.8
Change in shipper and carrier costs before user fee payments	0.4	0.4
Change in user fee payments	–0.6	0.8

In both scenarios, highway agency costs decrease (by $2.1 billion annually in the ideal pricing scenario and $1.8 billion with simplified pricing), primarily because of the change in pavement designs but also because the new fees induce truck operators or shippers to reduce axle loads, change truck configurations, shift some freight to rail, and (in the ideal pricing scenario) change routes to travel on roads with stronger pavements. Ideal pricing increases pavement wear savings only moderately compared with the simplified fees (by $2.1 billion minus $1.8 billion, or $300 million annually). In both scenarios, shipper and carrier costs before user fee payments increase (by $400 million annually) because of the changes in their operating practices induced by the fee changes. In the ideal pricing scenario, user fees paid by carriers decline and shippers and carriers realize a net gain of $600 million annually. However, in the simplified fee scenario, user fee payments increase by $800 million annually (because fees must be raised even on roads with low pavement costs in order to attain the optimum systemwide pavement savings), and shippers and carriers suffer a net loss.

Selection between the two tax schemes would be a policy choice that weighed the trade-offs involved. The potential economic benefit under ideal pricing would be greater, and the option would have the practical attraction that both shippers and highway agencies would gain. Potential savings from the simplified pricing system would be only a little less, and the fee scheme would be easier to administer, but the high fees required to gain the pavement savings might make the option politically unattractive.

This example is presented here not for the significance of its quantitative results [the authors of the study acknowledge that their estimation methods are very approximate, the data are now old, and the magnitudes of some impact estimates may have been distorted by problems in the U.S. Department of Transportation (USDOT) data employed)] but to illustrate the kind of comparison of economic consequences that ought to be the basis of evaluations of all transportation user fee schemes. Projections of economic impacts will always be uncertain; however, in practice, once an initial evaluation is made and a fee change put into effect, the consequences can be monitored and fees readjusted on the basis of new information.

In summary, the tax policy studies show that the criteria that the states and Congress recognize are revenue adequacy, fairness, and administrative practicality. Actual tax policies are driven by the objective of meeting revenue targets; however, in enacting transportation funding arrangements, governments generally have respected the user fee finance principle because it is seen as practical and fair. Explicit consideration of how changes in user fees and other funding arrangements will affect transportation system performance or the economic benefits derived from transportation programs seldom enters into finance or fee decisions. Nonetheless, it would be possible to compare fee alternatives on this basis and gain useful guidance for policy if a program were put in place to evaluate systematically the impacts of fees on the behavior of highway users and on the costs and benefits of the highway program.

HIGHWAY SYSTEM PERFORMANCE

This section summarizes estimates of the return earned by highway investments in recent decades. This information will help decide whether present finance arrangements are promoting sound decisions on capital spending levels and project selection. It was argued above that one mechanism by which present finance arrangements may affect system performance is through limiting total spending. A facility that provided a service whose value to users was less than the cost of providing the service probably could not generate enough revenue from user fees to sustain itself in the long run. Also, because fee levels are tied to spending, users have an incentive to oppose spending on a facility that is worth less to them than the

fees they pay. Therefore, user fee finance, as it is practiced in the highway program, might be expected to reduce the risk of overspending, that is, spending to provide services that are not justified by their benefits. In contrast, it might be expected that the risk of overspending is greater in other public infrastructure programs in which spending is not effectively limited by revenue from users, for example, inland waterways (where user fees cover one-eighth of total expenditures; see Table 2-6) and passenger rail (where fare revenue covers approximately half of expenses).

In opposition to this argument, critics of user fee finance have characterized dedicated highway user fee revenues as a cash cow providing funds regardless of justified needs and argue that public officials would do a better job of targeting funds to worthwhile applications if they were unhindered by the constraints of trust funds and dedicated taxes. Evidence concerning the economic return on highway investments would help in judging which of these two points of view is more accurate. If incremental investments are found to earn high rates of return, the case for the view that user fee finance promotes overspending is weakened and the view that present finance arrangements are a positive influence is strengthened, However, such evidence alone would not prove the linkage between present finance arrangements and performance.

The estimates discussed in this section include results from the latest of a biennial series of federal reports to Congress (formerly called the *National Highway Needs* reports and now the *Conditions and Performance* reports) on the performance of the highway system and several estimates by economists of incremental rates of return on highway investment. It has already been noted that quantitative information on the benefits of highway investment is much weaker than would be desirable for sound policy guidance.

Results from the *Conditions and Performance* studies are not presented here with the intent of arguing that highway spending should be increased.[3] As Chapter 1 states, the committee has not considered whether the present rate of transportation spending is too high or low, and its task does not involve finding revenue mechanisms capable of supporting increased spending. Rather, the studies' results are examined solely to investigate whether historical spending levels have been economically justified.

Because users of roads are not charged market prices, the benefits of road improvements to users must be estimated from various sources of information about the effect of road conditions on travel time, vehicle operating costs, and other components of the total cost of transportation. The absence of market pricing does not invalidate the estimates of the benefits of incremental expansions of

[3]The studies are commonly used for this purpose, e.g., by AASHTO (AASHTO 2002) and the Chamber of Commerce (Cambridge Systematics 2005).

the highway system presented below; however, if prices more closely reflected costs, greater benefit could be derived from existing facilities and service quality could be maintained in the future at lower total cost. Also summarized below are results of studies that estimate savings from better pricing.

Appendix A presents the estimates from the studies summarized here in more detail and describes the studies' methods, including some important shortcomings.

Federal Highway *Conditions and Performance* Studies

USDOT submits biennial reports to Congress that project the effects of alternative levels of highway capital spending (for all levels of government) on highway performance and highway user costs (travel time, vehicle operating costs, and accident costs). The 2002 study projections, for the period 2001–2020, indicate that if all highway capital projects nationwide with a benefit–cost ratio greater than 1 were carried out, annual capital spending over the period would average 65 percent higher than actual 2000 spending. To maintain overall conditions and performance at 2000 levels, annual capital spending 17 percent higher would be required (USDOT n.d., ES-14).

The 2002 study did not report rates of return. However, the previous study reported that if all projects with benefit–cost ratio greater than 1 were carried out over the 20-year period 1998–2017, the average benefit–cost ratio would be 3.7 (USDOT 2000). In comparing the mix of kinds of projects that highway agencies were carrying out in recent years with the mix of kinds of projects that would be most beneficial, the 2002 study concluded that benefits would be increased if agencies shifted spending from system preservation to capacity expansion (USDOT n.d., iii).

The 2002 study concluded that physical conditions of highways were unchanged or slightly improved during the 1990s. Performance was found to have deteriorated: the fraction of all travel on freeways and principal arterial streets that occurred under congested conditions increased. The projections show that, although spending more would slow the rate of deterioration, at all future spending levels analyzed up to the maximum economically justified level, congestion delay will increase or will be little improved (USDOT n.d., 9-8).

In summary, the USDOT *Conditions and Performance* studies indicate that the direct benefits to highway users of additional capital spending for highway system preservation and expansion would exceed the cost to the government and that spending would have to expand to a level substantially greater than present spending before highway agencies ran out of worthwhile projects. This conclusion implies a high marginal rate of return to increased spending and that total spending historically has been constrained within economically justified limits.

Productivity Benefits of Highway Investment

A series of economic studies has examined how highway infrastructure affects business costs for the national economy or for industry groups. Results of four such studies are outlined below. The first two measured the effect of highway investment on particular costs that have an evident link to highways: trucking company costs and industry inventory costs. The final two take a more aggregate approach and examine the historical contribution that expansion of the highway system has made to productivity growth in broad industry classes.

In spite of the differences in methods among the four studies, they all are attempts to measure approximately the same category of benefits. Savings in truck freight and the consequent savings in logistics costs (estimated in the first two studies) are the initial steps in a chain of transfers of the benefits of improved highway transportation. This chain leads to overall productivity growth (measured in the second pair of studies) and ultimately to lower prices for the goods and services that consumers purchase and to higher incomes. All of these studies' estimates exclude, by design, major components of highway benefits; in particular, they leave out most or all of the benefits of passenger travel. The findings, which are representative of recent credible research on the national economic return to highway investment in the United States, were as follows:

- The study of trucking (Keeler and Ying 1988) estimated the relationship of total annual production costs in the intercity trucking industry to industry output, the prices of inputs, and external factors that influence productivity, including the stock of highway infrastructure, for 1950 to 1973. The results show savings, for the total of U.S. intercity truck traffic that would have occurred without the expansion of the highway system, reaching $6 billion to $9 billion annually by 1973 (in 1973 dollars). These savings justified between 33 and 80 percent (depending on assumptions about interest rates) of the capital cost and 30 to 67 percent of the total cost of intercity highways during the period. Year-by-year estimates showed that by the early 1970s, the incremental benefits from increases in the highway capital stock were becoming very small.
- The inventory costs study (Shirley and Winston 2004) estimated the reduction in inventory holding costs and associated logistics costs in U.S. business caused by expansion of the highway system in the period 1973–1996. Transportation system improvements are expected to reduce inventory holding costs by increasing the speed and reliability with which firms can replenish inventory. The estimated annual rate of return on net investment in the highway capital stock was 18 percent during the 1970s (i.e., an additional dollar of net highway capital stock reduced costs by $0.18), 5 percent during the 1980s, and 1 percent during the 1990s.

- The first of the two studies of the link between highway capital expansion and industry productivity growth (Fernald 1999) used data on production and inputs for 29 industry groups for the period 1953–1989. It estimated the relationship of growth in total factor productivity in each sector to growth in the national highway system. The results indicate that for the period as a whole, road expansion contributed strongly to productivity growth and that the return on additional road investment greatly exceeded the normal private-sector rate of return. Separate estimates for the pre- and post-1973 periods indicated that after 1973, the estimate of rate of return was not statistically different from the normal rate of return or from zero.
- The second industry productivity study estimated the contribution of highway capital to productivity in 35 industries and in the entire U.S. economy for the period 1950–1991 (Nadiri and Mamuneas 1998). The model was more detailed than that of the previously described study. It found annual rates of return on additional highway capital of 54 percent for 1960–1969, 27 percent for 1970–1979, and 16 percent for 1980–1991. That is, in the 1980–1991 period, an incremental addition to the highway capital stock produced annual cost savings in private business equal to 16 percent of the total social cost of providing the additional capital. The authors observe that by the end of the study period, rates of return on highway capital and private-sector capital appear to have converged.

It is noteworthy that each of the four studies measured a decline over time in the benefits of incremental additions to the stock of highways. Interpreting the significance of this reported pattern is difficult because the timing of the declines is inconsistent among the four studies. The trucking cost study (Keeler and Ying 1988) and the first of the industry productivity studies (Fernald 1999) report that by the 1970s, the rate of return on highway expansion was nearing zero. However, the inventory cost study (Shirley and Winston 2004) and the second industry productivity study (Nadiri and Mamuneas 1998) measure 27 percent and 18 percent rates of return, respectively, during the 1970s. Of course, the four studies are measuring different components of total benefits, but the benefits measured are related, so consistent trends would be expected.

The authors of the trucking cost study observe that a decline in the benefits of expansion in the 1970s would not be implausible since by the early 1970s the basic network of Interstate highways had been completed. The authors observe also that at this time, expansion of the capital stock slowed markedly (growth in the stock of roads was 5 percent per year in 1955–1975 and 1 percent per year in 1975–1985; see Figure 2-12). They speculate that this brake on growth could have been the rational response of governments to the decline in the benefits of expansion. The inconsistent results among the studies, as well as certain simplifying assumptions and uncertainties embodied in the estimates (as described in

Appendix A), suggest that the studies' estimates of the time trends of returns may not have great reliability.

Regardless of the significance of the measured declines in returns over time, the estimates in these studies are evidence of positive rates of return on investments in incremental expansion of the U.S. highway system in the period from the 1950s to the 1990s. The studies considered only direct benefits (carrier operating costs or production costs of industries that use highway services in their production processes) and excluded large categories of benefits (including benefits of personal travel as well as certain benefits to businesses). They therefore provide additional support for the conclusion stated at the end of the previous section that, in the aggregate, the highway finance mechanisms that determine funding and priorities have been effective in providing funding to worthwhile projects and in keeping total spending within economically justifiable limits.

Cost of Inefficient Highway Use and Benefits from Improved Pricing

The preceding section presented evidence that the transportation finance system has on the whole helped to direct resources to worthwhile applications. Transportation programs also have several important failings that are related to the structure of the finance system. First, because highway agencies do not practice peak pricing, congestion is tolerated that could be avoided at relatively low cost. Second, some road users, including operators of certain types of trucks and buses, do not pay fees commensurate with the construction and maintenance costs that they impose on highway agencies. This misalignment of fees with costs encourages inefficient vehicle design and operating practices and adds unnecessarily to highway costs. Third, the finance system does not provide a strong internal check that individual projects are economically justified or that the most beneficial projects receive the highest priority.[4] Such a check would exist if projects were financed with funds they generated themselves (although it is likely that some road projects that produced benefits exceeding their costs could not be funded by revenue from marginal cost–based user fees alone). Finally, less spending for capacity expansion would be required to attain any given level of performance of the road system if pricing were improved. Because better pricing would lead to more efficient utilization of existing capacity, the amount of improvement to be gained from expansion would be reduced in many cases. Therefore, some highway projects that would be carried out according to today's practices (including projects that are fully

[4] The finance system does impose some constraints on project selection. Because most federal highway aid is apportioned by formula, each federal-aid project that a state chooses to construct has an opportunity cost—by selecting the project the state eliminates some other potential project. Also, because of federal grant matching requirements and the overall importance of state and local funding, spending tends to be directed to regions where demand is greatest.

justified economically under present practices) would no longer appear to be worth high priority in spending plans.

This section summarizes estimates of the costs of these shortcomings of present road management practices and of the potential benefits of extensive application of improved road pricing. Improved pricing means more closely matching the charge that each road user pays with the actual costs of the user's trip to the highway agency and the public. Under improved road pricing, charges could depend on distance, route, time of day, degree of congestion on the road, or other conditions affecting costs. However, pricing improvements do not have to be complex to be worthwhile. Simple refinements, such as adjusting registration fees in line with the results of cost allocation studies or instituting a peak-period toll on a toll bridge or high-occupancy/toll (HOT) lane, could have large benefits. Proposals for practical pricing improvements are described in Chapters 5 and 6.

The estimates summarized below relate to five issues:

- The costs of congestion today and the prospects for reducing costs through conventional means,
- The potential benefits of congestion reduction brought about by peak pricing,
- The potential contribution of refined truck fees to improving freight transportation efficiency,
- The potential revenue from road pricing, and
- How road pricing would affect perceived needs for capacity expansion.

Costs of Congestion and Prospects for Mitigation

Highway congestion causes several billion vehicle hours of delay annually, and only modest potential exists for cost-effectively reducing delay through traffic engineering improvements or capacity expansion.

USDOT's 2002 *Conditions and Performance* report (described earlier) estimates that annual congestion delay in 2000 was 31 hours per driver (the difference between total time spent on the road and time for the same travel if all traffic were free-flowing), or 6 billion total vehicle hours per year. The projections of impacts of alternative spending rates indicate that increasing annual capital spending to the maximum economically justified level (a 65 percent increase over 2000) would reduce annual driver delay per driver by 16 percent in 2020 and the fraction of all travel that occurs under congested conditions would continue to rise (USDOT n.d., 9-7).

The Texas Transportation Institute (TTI) Annual Urban Mobility Report series contains similar estimates: 3.5 billion vehicle hours of congestion delay and $9 billion of additional fuel consumption caused by congestion in 2001 in 75 met-

ropolitan areas (Shrank and Lomax 2003, Tables, A-5, A-7). TTI projects that more extensive application of three demand management techniques—traffic signal coordination, freeway incident management to clear crashes quickly, and freeway entrance ramp metering—could cost-effectively save 6 percent of estimated total congestion delay.

Benefits of Congestion Reduction Through Peak Pricing

Peak pricing on congested roads probably could bring about congestion reduction at least as great as the most ambitious justifiable program of capacity expansions and traffic engineering measures in the absence of pricing.

Peak pricing or congestion pricing is any scheme that imposes charges that are higher for travel on congested roads or during times of peak congestion than under uncongested conditions. The charges reflect the delay cost that each user imposes on other users during the peak. Peak pricing can take the form of a per-mile charge that depends on the time of day or the actual current congestion on a road, or it can take a simpler form such as the London congestion charging scheme under which motorists pay a fee to enter a central city zone.

The estimates of peak pricing impacts cited here and in the following three sections are all projections, because experience with these kinds of pricing mechanisms as a means of funding a road network is extremely limited.[5] Existing applications whose primary function is congestion relief in center cities—for example, the congestion charging scheme introduced in central London in 2003—demonstrate impacts of congestion pricing but are not directly relevant to this study's task of examining alternative means of funding highways, because road finance was not among their primary objectives.[6]

The committee that authored TRB's 1994 *Curbing Gridlock* study of the prospects for congestion pricing in urban areas concluded that practical applications could reduce the average automobile commute trip in congested metropolitan areas by 20 percent, or 10 to 15 minutes per round-trip, and that aggregate time savings would be "hundreds of millions of hours" annually (TRB 1994, 4). Such estimates assume that prices are set so as to maximize the public's travel benefits, that is, the difference between the benefits to those who gain from faster travel

[5] Chapter 6 describes the experience that does exist, including expressway segments with variable tolls in the United States and mileage fees imposed on trucks on some European expressways, and technological advances that have greatly reduced practical barriers to road pricing.

[6] The central London congestion charging scheme charges motorists £8 daily to drive or park in an 8-square-mile zone between 7:00 a.m. and 6:30 p.m. on weekdays. The scheme has reduced average automobile trip times by 1 minute per mile and automobile traffic by 18 percent in the zone. Net revenue, £97 million in 2004, is mostly dedicated to the bus system (TfL 2005). The transport agency's monitoring reports do not address whether the benefits from faster travel times outweigh the costs of trips forgone or diverted to other modes.

and the losses to those who lose mobility because they do not want to pay the charges. Obviously, it would be possible to eliminate congestion if prices were high enough, but such a policy would not be desirable as a rule because prices would be so high that many trips that were worth more to the traveler than their cost to the public would be priced off the roads.

Truck Fees and Freight Transportation Efficiency

Misaligned truck fees cause inefficiencies in road construction and maintenance and in freight transportation costs.

Past TRB committees have estimated that coordinated changes in truck fees, size and weight regulations, and road design could produce net savings to the public equivalent to $4 billion to $9 billion annually at today's prices and traffic volume (TRB 1990a, 12–22; TRB 1990b, 3–14; TRB 2002, 2–11). Under some proposed policies, both shippers' freight costs and highway agencies' construction and maintenance costs would fall. Under other proposals, highway agency costs in a state could increase or decrease, depending on the previous condition of the infrastructure, but extra highway spending would be worth the freight savings it allowed. In either case, charging truck operators fees closely aligned with the costs of serving them is key to the policy. The fees would encourage operators to choose truck specifications, operating practices, and routes that minimized the sum of public and private costs, and they would be a revenue source to finance infrastructure improvements needed to serve trucks. Funding the improvements from fees would provide a check that helped to ensure that the improvements were worthwhile.

Potential Revenue from Improved Road Pricing

An efficiently sized road system could pay for itself from the revenues generated by peak charges, plus possibly an additional flat per-mile fee or registration fee.

Economists have long argued that the correct size of the transportation network that should be built is the size that could support itself with the revenue from user charges, if charges equal the cost of providing service to each user. Parts of the network that are generating surpluses should be expanded, and (with some exceptions) parts operating at a deficit should be allowed to contract.[7] Results of some empirical analyses of road economics suggest how such a road finance system could work in practice.

[7] The appropriate charge is the short-run marginal cost of the trip, that is, the added cost of one additional trip over the network to the system operator, other users, and the public. This includes the added congestion cost to other users. Marginal cost pricing will lead to the optimum-sized system if there are no scale economies—that is, if the total cost of providing service grows proportionally to the size of the network (Mohring 1965, 232–241).

The Brookings *Road Work* study modeled the finances of hypothetical urban road segments on which users are charged fees equal to marginal congestion and road wear costs of their travel (Small et al. 1989, 108–109). The study estimated the economically optimum designs (numbers of lanes, pavement durability, and congestion levels), maintenance and capital costs, and user charges for expressways and nonexpressway arterial roads carrying various volumes of automobile and heavy truck traffic. In the results, the peak-period volume–capacity ratio on the optimized urban expressways is around 0.74. For comparison, about half of all miles of urban expressway travel today is on roads with volume–capacity ratio over 0.8 (USDOT n.d., 4-15). (The authors caution that the purpose of the study is not to judge whether existing road designs are appropriate because the best design depends on numerous specific local circumstances.)

Over a wide range of volumes, the optimized urban expressways and nonexpressway arterial roads would nearly be able to cover total capital and maintenance costs from the revenues of congestion and road wear charges. Estimated deficits are a few percent of total costs and depend on assumptions concerning scale economies in road construction. Typical peak-period charges would be equivalent to $0.30 per mile for cars and $0.60 per mile for large trucks in 2005 dollars. Trucks would also pay a road wear charge at all times ($0.01 to $0.08 per mile in 2005 dollars, depending on road design). The authors comment that any deficit could be closed by retaining small registration fees or fuel taxes; it could also be covered by a small flat-rate off-peak mileage charge.

Recent projections of the impact of practical road pricing schemes in metropolitan Washington, D.C., give a more detailed indication of possible consequences for highway performance and finance. The study used a detailed network model of the region's highway and transit systems to forecast the effect of alternative road pricing policies on travel and congestion, the revenues from road charges, and differences in impacts among income groups (Safirova et al. 2004). The transportation system and locations of jobs and residences are assumed to be fixed. The three policies examined are converting existing high-occupancy vehicle (HOV) lanes into HOT lanes (which admit high-occupancy vehicles for free or any vehicle that pays a toll), charging tolls on all lanes of expressways that now have HOV lanes, and charging on all lanes of all major freeways. Only simple fee structures are considered: fees differ among two or three road classes and two daily time periods.

In the most comprehensive pricing option (charging on all lanes of all major freeways), single-occupancy vehicles pay a toll of $0.22 per mile to travel on former HOV lanes, and all vehicles pay $0.07 per mile on non-HOV expressways, during peak periods. Tolls are selected to maximize the benefit of pricing, which equals the value of net travel time savings from reduced congestion plus the benefits to travelers of new trips stimulated by the reduced congestion, less the losses from trips that are no longer made. The benefit of the policy is $220 million per

year, which is equal to 19 percent of pretolling congestion costs. Toll revenue is $446 million per year, and the travelers in every income group gain less in time savings than they pay in tolls. Since tolls are a transfer from travelers to the road authority, the public as a whole gains. Remarkably, the benefit from converting all existing HOV lanes into HOT lanes is projected to be $170 million per year, 77 percent of the benefit from tolling all expressways. Benefits could be increased if a more refined fee structure were employed (e.g., adjusting fees according to actual congestion and imposing fees on a larger portion of the road system). The authors note that these estimates reflect only the gains from reducing recurrent congestion (i.e., congestion not caused by accidents, construction, or other exceptional events) and assert that taking into account the effect of pricing in reducing the costs of nonrecurrent congestion would result in larger estimates of benefits.

The projected revenue for the policy of tolling all expressways is roughly comparable with current annual expenditures on expressway construction, maintenance, and operation in the Washington metropolitan region (FHWA 2004, Tables SF-12, HF-10). The absence of tolls on roads other than expressways in the projections limits expressway revenue, because tolls must be set low enough to avoid excessive congestion on parallel untolled roads. Under a policy of charging peak mileage fees on expressways only, optimum tolls should not be expected to raise revenue sufficient to fund the optimum level of spending. If mileage charges were imposed on roads other than expressways, the revenue-generating capacity of expressways would be greater. Another recent estimate puts the potential revenue from comprehensive road pricing in metropolitan Washington at $700 million annually (Nelson et al. 2002).

The estimates of the revenue potential of road pricing cited here all apply to urban road networks. Rural roads (ranging from Interstate highways to local farm access roads) account for 40 percent of state government highway spending (FHWA 2004, Table SF-12) and probably a comparable share of local spending. Most rural road mileage would generate no revenue from congestion fees. If a networkwide system of mileage charging (such as the proposals described in Chapter 5) were to come into use, the pricing and investment rules and financing practices for rural roads would probably have to be different from those for the urban parts of the system. Revenues from marginal cost–based fees would cover an important part of the cost of rural roads, including pavement and bridge wear costs attributable to traffic, and congested rural roads (e.g., certain heavily traveled Interstates) would generate congestion fee revenue to pay for capacity expansion. Rural roads that are maintained primarily for the sake of a social interest in sustaining rural communities and farms could appropriately be subsidized out of government general revenue. However, investment in some rural roads may be economically justified by their direct transportation benefits even though the roads could not be funded by revenue from marginal cost–based fees (because there is a minimum scale to which a road can be built). Such roads could be funded by flat-rate mileage

charges or property tax assessments. If such roads were funded by user fees, rates would be selected to minimize the loss caused by overcharging for roads that have low operating costs.

Road Pricing and Capacity Expansion

Improving road pricing would alter the benefits of capacity expansion projects and therefore would be expected to affect project selection and the rate and direction of evolution of the network.

The TRB *Curbing Gridlock* committee predicted that peak pricing would "reduce the demand for new highway capacity in urban areas . . . [and] ease capital requirements for expanding highways" (TRB 1994, 46). Because better pricing would lead to more efficient utilization of existing capacity, the amount of improvement to be gained from expansion would be reduced in many cases. Therefore, some highway projects that would be carried out according to today's practices (including projects that are fully justified economically under present practices) would no longer appear to be worth high priority in spending plans. Improved road pricing would also highlight parts of the network where capacity has been underfunded because these roads would be able to generate surplus revenue.

One study examining these long-run effects used a network model to project benefits of four hypothetical expansions to the road network of the city of Cardiff in the United Kingdom, under present practices and with congestion charges imposed on motorists on all roads (Williams et al. 2001). The four projects were a bypass, a new road link to the city center, an expansion of a through route across the center, and a partial bypass. The projected benefits of the first three projects were lower if congestion pricing was in place for a wide range of assumed rates of traffic growth. For example, the travel time savings produced by the bypass and the through route expansion are up to 30 percent less with congestion pricing because speeds on preexisting roads are higher and because less total travel takes place. (In the case of the fourth project, pricing diverts much traffic to the new road, rendering it more valuable.) The study illustrates that some projects, which may produce benefits that fully justify their costs in the absence of congestion pricing, would cease to be economically attractive if pricing were introduced.

In general, improved pricing would reduce the infrastructure cost of attaining any specified level of service quality. However, there would be locations where highly congested roads were yielding surplus revenues and expansion of capacity would be economically justified and practical. Then the highway agency would have the funds (if fee revenue were dedicated to transportation) and the justification to expand capacity and improve service. In regions where highways are underfunded, the result of road pricing could be increased construction spending.

Summary: Relevance of Performance Evaluations to Finance

Although the evidence is fragmentary, available estimates indicate that the investment embodied in the present highway system as a whole has been beneficial, that total spending probably has not greatly exceeded (and may be less than) the amount that would be economically justified, and that opportunities exist for investments in incremental expansion and upgrading of the system that would yield worthwhile payoffs.

The paucity of data makes comparisons difficult, but there appear to be public infrastructure programs in the United States that have not had this degree of success—that is, programs in which total spending has significantly exceeded justified levels and in which incremental investments are being directed to projects with low returns. It is likely that the financial checks and balances in the highway finance system have contributed to the relative success of the highway program in producing a satisfactory return from the public funds invested. The fuel taxes and vehicle fees that users pay are about 10 percent of the private cost of operating a motor vehicle. They vary with use and have been adjusted from time to time in accordance with changes in the cost to the government of providing highways. Therefore the fees, to a limited extent, discourage wasteful use of the system.

More significant, spending has been constrained by the revenues generated from users. Reliance on user fee finance should reduce the risk of excessive spending: an overbuilt facility that produced low levels of benefits for its users in relation to its costs would be unlikely to generate revenue from user fees sufficient to sustain the facility. Also, in the political process of setting highway budgets and fees and selecting projects, users are unlikely to support fee levels in excess of those producing benefits the users consider worthwhile. And with total spending subject to a budget constraint, users will be likely to oppose projects that yield lower returns than other available projects.

However, the present finance system has important shortcomings that reduce the benefits of transportation programs. The following conclusions are supported by the review above of the costs of these shortcomings and the potential benefits of finance reform that incorporated improved road pricing:

- Highway congestion causes several billion vehicle hours of delay annually, and only modest potential exists for cost-effectively reducing delay through traffic engineering improvements or capacity expansion.
- Peak pricing on congested roads could bring about congestion reduction and public benefits at least as great as justifiable capacity expansions and traffic engineering measures in the absence of pricing.
- Better aligning truck fees with the costs of serving trucks would yield efficiencies in road construction and maintenance and in freight transportation.

- An efficiently sized road system (that is, a system that could not be expanded or contracted without loss of benefits) could pay for itself from the revenues generated by peak charges at rates that maximized public benefits, plus probably modest additional flat per-mile or registration fees.
- Improving road pricing would alter the benefits of capacity expansion projects and therefore would be expected to affect project selection and the rate and direction of evolution of the network.

TRANSIT PERFORMANCE

The impetus for this study was concern for the viability of present highway user fees as a revenue source. Therefore, the committee has considered transit finance insofar as it is linked to highway user fees. A prominent feature of the present finance system is the dedication of portions of federal and state highway user fee revenues to transit. As Chapter 2 described, the amounts are fairly modest compared with total highway spending but are important for transit, amounting to about a quarter of transit spending.

A part of the committee's charge (presented in Chapter 1) is to assess the implications of finance trends for the performance of the transportation system and whether benefits could be attained through reform. Therefore, it is relevant to the charge to examine the economic performance of transit in parallel with the review of highway system economic performance above. The examination will help in judging whether the practice of partially funding transit with highway user fee revenue is justified economically today and whether it ought to be continued if a transition to new funding sources takes place in the future.

This section addresses the first of these questions: whether the public derives benefits from subsidies to transit (i.e., funding from sources other than fare revenues from operations). In Chapter 6, highway user fee revenue and alternative sources for such funding are compared. At least two characteristics of urban transportation may justify subsidies to transit. Highway travelers do not pay the full costs to the public of their trips, especially trips during congested periods. Therefore, some road trips cost the public more than they are worth to the traveler, and a subsidy to transit that diverts some trips from highways can yield a net public benefit. Second, there are scale economies in the provision of transit services over a wide range of passenger volumes. That is, at least in some circumstances, the long-run cost per passenger falls as volume increases (and capacity is expanded to accommodate it). In these circumstances, additional passengers lower the costs for all in the long run, and the public can gain from a transit subsidy that increases traffic volume. Of these two possible benefits from transit subsidies, the benefit from congestion reduction is the better documented and probably the larger benefit in cities today. If highway subsidies were reduced or eliminated in the future

(e.g., through mileage charges as described in Chapter 5), it might become more important to take scale economies into account in transit finance. There also may be scale economies in the provision of highway transportation (Gómez-Ibáñez 1999, 112–114; Small 2006; Mohring 1965, 253–254; Meyer et al. 1965, 341–344).

As in the case of highways, few estimates of the historical benefits of transit programs have been carried out. USDOT's *Conditions and Performance* reports consider transit; however, the method differs from its analysis of highways described above. The USDOT reports present estimates of transit spending levels required to meet specified service criteria but not of economically justified spending (USDOT n.d., iv). Summarized below are the results of two studies that do assess whether the present level of subsidies is appropriate by estimating benefits from transit.

The first study, from the Brookings Institution, used an urban transportation demand model to estimate the value that travelers place on bus, rail transit, and road travel (Winston and Shirley 1998, 29–47). The demand model relates travelers' choices about transportation mode and the timing of trips to measures of transportation service quality and cost. The model was used to calculate the payment that would be required to compensate travelers for their loss if their preferred mode was unavailable. The calculation includes the loss to automobile travelers when elimination of transit increases highway congestion.

These estimates of the benefit that travelers derive from each mode are then compared with government subsidies to the modes. The estimated annual benefit of bus service to travelers in 1990 was $4 billion (in excess of bus fares paid, and including the benefit to automobile travelers of reduced highway congestion). The study estimates 1990 bus subsidies to be $10 billion and concludes that the subsidies were not cost-effective, since their discontinuance would have resulted in a loss of at most $4 billion in benefits. Highways are estimated to yield large net benefits. For rail transit, the benefit to travelers, $3 billion, just equaled government subsidies. The authors emphasize that the benefits and costs of bus and rail systems vary from city to city and that with appropriate service and pricing, bus systems could generate positive benefits.

The Federal Transit Administration (FTA) has evaluated the economic performance of transit with a conceptually similar method (FTA 2000, 37–52). The result is expressed as the optimal subsidy that the public ought to pay to transit to allow it to lower its fares to attract travelers off roads. The study recognizes that the primary economic rationale for transit subsidies is that urban highway use generally is undercharged. Because a highway traveler does not pay a price for using a congested road that reflects the cost (in added travel time) the traveler imposes on others on the road, some trips cost the public as a whole more than they are worth to the individual traveler. If congestion charges cannot be imposed on roads, the public can benefit by subsidizing transit as long as the cost of attracting an addi-

tional traveler from road to transit is less than the public benefit of the resulting reduction in road congestion. The FTA analysis uses an urban travel demand model to compute this optimum annual subsidy for seven metropolitan areas and the nation as a whole.

The resulting estimate is that the optimal nationwide annual transit subsidy in 1999 was $19 billion ($10 billion for bus and $9 billion for rail). Actual transit operating subsidies (i.e., operating expenses less fare revenue and other revenues from operations) in 1999 were $13 billion and capital grants were $9 billion (APTA 2004, 37, 44, 46; Table 2-4, Chapter 2). The study concludes that the optimum subsidy exceeds the actual operating subsidy plus that portion of capital spending devoted to maintaining and renovating existing capacity, and therefore that transit subsidies for these purposes are economically justified.

Comparison of the FTA study estimates with actual subsidies suggests that, although their total magnitude may be appropriate, present subsidies are misallocated. For example, FTA's metropolitan area estimates indicate that New York should receive 39 percent of all subsidies, whereas New York City Transit's share of nationwide operating subsidies is 12 percent (FTA 2004). The FTA study estimates that rail transit's share of the optimum subsidy should be 46 percent, but according to the Brookings study, rail in 1990 received only 23 percent of actual subsidies.

In summary, the two studies indicate that the present nationwide total level of rail transit subsidies and at least some part of bus subsidies are justified by the benefits to travelers, although benefits probably could be increased by shifting subsidies in favor of the more transit-dependent cities and rail. Transit subsidies can be of benefit because urban road users are not charged fees commensurate with costs. Therefore, improving the pricing of roads would alter the rationale for transit subsidies.

EVALUATION OF FINANCE PROGRAM FEATURES

The conclusions of the section above on highway system performance were that, although the quality of the evidence is weak, the highway program appears to be relatively successful in providing benefits that justify its costs and that the finance system probably has contributed to this success because user fees function as prices and because user fee finance tends to check excessive spending. However, the connections between performance and the particular features of the finance system are complex and not well understood. Aspects of present practices have been controversial, and proposals to modify them are common.

The two defining features of the system are the practice of user fee finance, which tends to link fee revenue to spending, and the federal structure of the system, that is, the sharing of responsibilities among federal, state, and local

governments. Understanding of the impacts of these two features will be necessary to guide either improvements in present arrangements or design of a long-term alternative. If the present system is basically sound, it will be valuable to extend its life span by reinforcing finance practices that contribute to its success and altering those that do not. For example, Chapter 2 described how pressures to find expedient funding are prompting some jurisdictions to decrease reliance on user fee revenue for transportation programs. If user fee finance has historically contributed to good performance, the risk involved in allowing the practice to erode ought to be considered in such decisions. Similarly, if adjustments to the rules of the federal-aid program could promote more cost-effective state and local government spending choices, such actions would reinforce the existing federal structure of transportation programs and extend the life of the present finance system.

If the nation eventually develops fundamentally new finance arrangements that rely more on direct charging for highway use (for example, through expanded use of tolls and road use metering, as Chapter 5 describes), governments will need to reconsider both these features of the finance system (the federal structure and the link between fee revenue and spending). With direct charging, the capability of states and local jurisdictions to collect fees from all users of their roads would be enhanced, so the historical justification for intergovernmental aid would be diminished, and jurisdictions would expect to control the revenue generated by the roads that they own. If the road user fees in the new charging scheme properly reflected costs, it would be appropriate to have tighter links between revenue and spending than exist today, because the revenue that each link in the road network generated would be the best indicator of the value of expanding that part of the network. Present practices with regard to government responsibilities, trust funds, and dedicated revenues were developed in the context of the existing scheme of funding sources. Simply substituting new sources for the existing ones while leaving all other finance practices untouched probably will not be practical or desirable.

The following two sections briefly outline key questions concerning the impacts of user fee finance and the federal structure of finance on the performance of government transportation programs. Adequate information for answering many of the questions is not available. Chapter 6 reviews proposals from various sources for changing certain of these features to improve performance.

User Fee Finance and Dedicated Revenues

Chapter 2 outlined federal highway finance practices. Most states' finance practices parallel the main features of the federal program—user fees, trust funds, and dedication of fee revenues for specific purposes. This collection of practices influences total spending, spending priorities, the use of roads and transit, and consequently the benefits of transportation programs. That is, the outcomes of transportation programs would be different if alternative practices were employed

(for example, eliminating the connection between user fee revenue and spending). The following practices are the elements of user fee finance in the highway program:

- Imposing highway user fees (principally motor fuel taxes and vehicle registration fees);
- Matching the fees, to some extent, to the government's costs of providing services;
- Dedicating most revenue from the fees to highways and transit, with trust funds to enforce the connection between revenue and spending; and
- Deriving most highway funding from highway user fee revenues.

This finance arrangement is the outcome of two independent policy decisions, each of which should be evaluated on its own merits: the decision to impose fees related (to some extent) to costs and the decision to depend primarily on fee revenue to fund highways.

User Fees

The practice of charging fees to highway users generally has not attracted criticism (although the level and form of fees can be controversial). The federal government, all the states, and most other developed countries impose special fees or taxes on road users, and similar charges are imposed on users of other government-provided transportation facilities in the United States.

Even if they are uncontroversial, user fees can be harmful if the charges that travelers incur for many trips exceed the added cost to the public of providing those trips. User fees can promote efficient use of facilities if they bear at least a degree of correspondence to the public's costs of providing the facilities. Then users will make decisions (e.g., whether to make a trip, whether to travel by car or bus, what size of freight truck to use, whether to ship by truck or rail) that take these costs into account. Fees set too low allow wasteful use of facilities, and fees set too high needlessly discourage travel.

Many studies have compared highway user fees with costs. One recent economic study that considered congestion, pollution, and the external costs of highway accidents concluded that, in the absence of more effective policies to address these costs (for example, peak period charges that reduced congestion), the optimal gasoline tax in the United States would be $1 per gallon (Parry 2002) (the actual average rate is $0.38 per gallon). (A tax at this level would discourage much travel on uncongested rural roads that was valuable to travelers and had low cost.) Of the $1 per gallon estimate, $0.20 would serve to substitute fuel tax revenue for some of the revenue now derived from income taxes. The public could benefit

from such a substitution because all taxes distort private economic decisions and thus cause economic losses. For example, road user taxes in excess of the costs of travel cause the loss of some valuable travel, and income taxes reduce employment. The study estimated that up to $0.20 per gallon, the added loss of this kind from the fuel tax would be less than the gain from lower income taxes.

In another study, a TRB committee compared prices with costs of freight transportation by truck, barge, and rail. The committee considered infrastructure, pollution, congestion, and accidents. It found that, for typical trips where the modes compete, the mismatch between prices (including user fees for public infrastructure) and costs for trucks usually was smaller than the mismatch for barges and greater than for rail (TRB 1996, 6–10). Chapter 6 describes proposals from federal highway cost allocation studies and past TRB committees for improving the alignment between present highway user fees and costs. Introduction of road use metering or other forms of congestion charging, as described in Chapter 5, would be needed to allow fees to reflect adequately the congestion costs that road users impose on others.

Dedicated Revenues

The other main feature of user fee finance in the highway program—the practice of tying spending on a particular government program to revenue from a particular tax—has been controversial. Analyses of dedicated taxes have produced at least four competing assessments:

- Dedicated taxes are harmful because any constraint that prevents government officials from allocating funds to the activities that will yield the greatest benefit will reduce public welfare. In this view, the revenue a particular tax happens to raise in a time period is a poorer guide to appropriate spending than the judgment of officials (Wilkinson 1994, 122; Buchanan 1963, 457).
- Dedicated taxes are justifiable as an expediency to gain public acceptance of certain worthwhile taxes or programs and to provide financial stability, even if the practice does tend to reduce the efficiency of government spending by limiting officials' flexibility. According to this pragmatic view, citizens who are skeptical of the benefits of general tax increases are more likely to acquiesce to a tax that is presented as supporting a specific popular program (Farrell 1999, 59; Wilkinson 1994, 120–122, 132). The financial stability provided by guaranteed revenue is viewed as necessary in an infrastructure program that must construct and operate large, long-lived facilities.
- Dedicated taxes promote efficient government by giving taxpayers more direct control over the uses of tax revenue. In this view, the constraint that earmarking places on the independence of government budget makers is

likely to enhance rather than reduce the efficiency of public spending decisions in many circumstances, because citizens know best what programs are worth and public officials often have biases stemming from their bureaucratic interests. Under general fund budgeting, the main choice for each citizen is whether to support higher or lower general taxes, and each citizen must speculate as to whether raising general taxes will sufficiently increase spending on the services he or she most values to make the general tax increase worthwhile. In contrast, dedicating tax revenues to particular uses creates opportunities for more direct citizen input to individual program funding decisions (Buchanan 1963).

- Dedicating taxes has little or no impact. Government officials generally have enough budgeting flexibility, despite restrictions from dedicated taxes, that total spending and spending allocations end up close to the amounts that would occur under general fund financing. In this view, it is a deception to lead taxpayers and voters to believe that dedicating taxes controls or guarantees spending choices when in reality it does not (Patashnik 2000, 188; Wilkinson 1994, 122).

These views are hypotheses about the merits of dedicated tax financing in general, including such applications as school district property and sales taxes to fund education. The highway finance system is a special case; because the dedicated taxes are user fees, they may have consequences that differ from those of dedicated broad-based taxes (such as a school district tax). Specifically, the willingness of highway users to pay the fee conveys some information about the value of the highway facility. It was argued above that reliance on dedicated revenue from user fees may reduce the risk of overspending, because a facility that produced little benefit would not generate fee revenue sufficient to sustain it and because users will not lobby for added spending that entails fees higher than the value to them of the improved service. Demonstrating that transportation spending is constrained in this way would require research, but there is some evidence in support of the assertion. National highway spending has historically tracked user fee revenue fairly closely (Table 2-3), although spending exceeds revenues and there have been periods of divergence (e.g., 1972–1982 and 1997–2003). Another sign of how finance practice constrains spending was the 2-year delay in reauthorization of the federal surface transportation aid program between the expiration of the previous program in 2003 and enactment of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005. The obstacle to action in that period was the gap between desired spending and projected revenue from user fees.

Gaining the efficiency benefits of charging fees to highway users does not require that the revenues raised be dedicated to highways. User fees are beneficial

as long as they induce reductions in costs of highway travel (for example, congestion, pollution, or road wear costs) that are greater than the value of lost travel benefits to highway users who forgo or alter travel because of the fees. It was noted above that if the charge for each trip is the marginal cost of the trip (that is, the added cost of the trip to the system operator, other users, and the public), and the highway agency invests in expanding links of the system that are generating surplus revenue, then the highway system will evolve toward the economically optimum scale and the fee revenue will approximate the spending needed to support it. However, if fees are not equal to marginal costs (for example, if a monopolist set fees so as to maximize revenue), then, in the case of a service like highways that users value highly and whose use is fairly insensitive to price, the fees could generate large revenues, in excess of the economically justified level of road spending.

The possibility of excess revenue has been a long-standing objection to dedicated funding for highways, whether from fuel taxes or tolls.[8] The legitimacy of this concern is difficult to assess because of lack of evidence. If road charges were set to maximize revenue and all revenue was then spent on expanding capacity, the likely result would be a growing capacity surplus and low or negative returns on investments for incremental capacity expansion. However, the evidence presented in the section above on highway system performance suggests that historically, incremental highway expansions have yielded good returns on average. Comparison of tax rates and revenues in the United States with those in Europe (where the gasoline fuel tax rate typically is 10 times higher than in the United States and revenues generally are not dedicated) suggests that U.S. rates are far below the revenue-maximizing rates. It has been argued that dedication of revenue tends to suppress fuel tax rates by making the fuel tax a less useful revenue-raising instrument in the eyes of legislators (Pisarski 2004).

Evidence for another supposed effect of dedicating tax revenue—that it gains public support for user fees or other taxes—is mainly anecdotal. The following are examples:

- In debates over transportation finance in Pennsylvania, rural and small town legislators are reported to have opposed proposals to increase highway user fees to pay for transit but to have supported a broad-based transit tax plus user fee increases dedicated to highways (Barnes 2005).

[8] For example: "The net result [of tying spending to revenue from road pricing] could be an inexhaustible supply of capital for highway investment unrelated to desired levels that might otherwise be formulated from policy planning considerations at the local or national level" (Sitton 1965); and "Originally intended to ensure completion of the interstates [the Highway Trust Fund] is now primed to sponsor much superfluous road construction. A bulging stream of proceeds from the trust's 'user fee' (gas-tax income) is presumed to pay for each new mile of concrete and macadam. . . . Few other advanced nations have hitched the financing of their transportation systems to a cash cow of this sort" (Nivola 1999, 69).

- Proponents of devolution of highway finance responsibilities from the federal government to the states regularly cite diversion of federal user fee revenue from highways to other purposes as a primary argument for abolishing the federal gas tax (e.g., Utt 2004, 2).
- A referendum calling for dedication of state highway user fee revenue to transportation passed by a 79 percent majority in Missouri in 2004 (ARTBA 2004).
- The history of transportation funding referenda suggests that the more specific the proposed uses of the revenue, the more likely it is that voters will support the tax (Ernst et al. 2002, 5–11; Center for Transportation Excellence 2004).

Experience in Europe runs counter to the claim that dedication of revenues is necessary to gain support of fees. Taxpayers there have been willing to accept very high fuel excise tax rates, although most revenue is not dedicated to transportation and some toll revenues have been dedicated to nonhighway purposes. However, the direction of European transport finance reform may be toward U.S.-style user fee finance with dedicated taxes (Commission on Transport Infrastructure Funding 2000).

In view of the fundamental importance of dedicated tax revenues to the financing of transportation programs in the United States, it is unfortunate that better information is not available for assessing the conflicting claims concerning the impacts of the practice. Research could evaluate the effect of the practice on total spending, public support for taxes, and the quality of government spending decisions. Despite the uncertainties, it appears that the practice of user fee finance in the highway program has positive consequences and that allowing the practice to erode would risk a decline in the performance of transportation programs. User fee finance appears in some cases to earn public support for specific programs, although systematic evidence for this effect is lacking. It provides stability and may promote efficiency through the budget constraint it imposes and through the influence of fees on user decisions.

Federal, State, and Local Government Responsibilities

Chapter 2 described the division of responsibilities among the federal, state, and local governments for finance and for operation of transportation programs, and it outlined the rules governing the federal-aid highway program with regard to allocations of grants among the states, project eligibility, project design, and contracting and labor practices requirements. These two related aspects of the federal structure of transportation finance—the division of responsibilities and federal program rules—exert a major influence on program outcomes.

Chapter 1 stated, as a guideline for policy, that the lowest level of government (federal, state, or local) that represents most of the population that uses and benefits from a transportation facility ought to be responsible for providing and funding the facility. That is, ideally, local governments would provide local streets and transit; states, regional facilities like intercity roads; and the federal government, facilities whose scope genuinely demands a national perspective in planning, like the Interstate highway system or the air traffic control system. The advantage of following this rule is that the governmental unit providing the facility is accountable to the users and beneficiaries of the facility, who also pay for it through their taxes and fees. Transportation budgets and priorities are then more likely to correspond to the services that the beneficiaries value most and are willing to pay for.

The federal and state roles in highways and transit are greater today than this rule would appear to require, for three reasons. First, grants to lower levels of government have been used as a means of redistributing resources among regions of the country and between urban and rural areas. Second, cities and towns lack good mechanisms for charging the users of their streets and highways. Finally, the present federal highway program was designed with construction of the Interstate system—a genuinely national project—as its most important objective. Since the substantial completion of the Interstate program in the 1980s, proposals have regularly been made to reduce the federal government's involvement in highways and transit. At the state level, a realignment of state and local responsibilities has occurred gradually, in part as the result of federal-aid program requirements that states give local governments more control over priorities for spending federal-aid funds in urban areas. Chapter 6 reviews a range of proposals for adjusting federal, state, and local roles, within the basic framework of existing finance arrangements, with the aim of increasing the cost-effectiveness of highway and transit spending. Chapter 5 describes proposals for introducing direct charging for road use through tolls or road use metering. By giving all governments the ability to raise revenues from all users of their roads, direct charging probably would entail a major restructuring of federal, state, and local responsibilities.

The following are important issues concerning the effects of program rules in the existing federal transportation aid program:

- The impact of project eligibility rules on state project selection (federal grants carry numerous restrictions concerning the class of road or the type of improvement for which the state may spend the funds, including the restriction of nearly all highway grants to capital projects);
- The effect of federal engineering standards and planning requirements on the cost-effectiveness of projects and project selection;
- The significance of the geographical transfers that the federal-aid program accomplishes, among states and between urban and rural areas, from the standpoint of fairness and cost-effectiveness; and

- The effect of the federal highway user taxes on state tax effort and the effect of federal-aid matching requirements on total state transportation spending.

There is scope for reforms in federal-aid program rules that would allow the program to produce greater transportation improvement and fulfill federal goals more effectively. Studies from government and other sources have suggested how changing specific rules could improve results. For example, Government Accountability Office (GAO) reports have shown that, because the state matching share required in most federal-aid highway projects is small (usually 20 percent), much federal highway aid is in effect paying for general state spending and taxpayer relief rather than for expanding the highway system (GAO 2004); a Congressional Budget Office study noted how relaxation of federal restrictions on debt financing, tolling, and public–private partnerships has helped states to increase the value of federal aid, and assessed prospects for greater improvement in this direction (CBO 1998); and a study by a TRB committee showed how federal design rules affect costs of projects and state project selection decisions (TRB 1987).

Revisions to federal-aid highway program rules would be a necessary element of any comprehensive proposal concerning reform of transportation finance at the federal level. In the 2005 reauthorization of the federal surface transportation aid program, Congress created two commissions to examine questions related to finance, the National Surface Transportation Policy and Revenue Study Commission [SAFETEA-LU Section 1909(b)] and the National Surface Transportation Infrastructure Financing Commission (SAFETEA-LU Section 11142). When the provisions in the charges of these commissions were under consideration during debate over reauthorization, GAO recommended that the mandate include consideration of options to redesign the structure and funding formulas of the federal-aid highway program, in order to increase the effectiveness of aid and better promote national goals (GAO 2004, 47). The commissions' charges do not specifically refer to this task, but it would not be inconsistent with the broad definitions of the charges in the legislation.

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ARTBA	American Road and Transportation Builders Association
CBO	Congressional Budget Office
FHWA	Federal Highway Administration

FTA	Federal Transit Administration
GAO	Government Accountability Office
TfL	Transport for London
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

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Effects of Automotive Technology, Energy, and Regulatory Developments on Finance

Important policy initiatives of the federal and some state governments have the goal of reducing oil use in order to reduce dependence on foreign oil suppliers and emissions of greenhouse gases and other pollutants. This chapter examines the extent to which revenue from highway user fees might diminish over time as the result of these policies. Reduced oil consumption will reduce revenues if tax rates are not raised to compensate. Transportation officials' apprehension in this regard is understandable in light of the history of tax rates and revenues described in Chapter 2. Rapid improvement in fuel economy and higher fuel prices were among the factors that contributed to the pronounced decline in constant-dollar highway user fee revenue and highway spending in the 1970s and early 1980s, until legislatures responded with rate increases.

This chapter examines the likelihood that rising fuel prices, new automotive technology, or new environmental and energy regulations will affect revenues from highway user fees in the next two decades. If large improvements in fuel economy or transition of the highway fleet to new energy sources appears likely within this period, planning for adjustment or replacement of the present fuel-tax-based finance system will be needed to avoid unintended declines in revenue. The first two sections below review projections of world petroleum supply, consumption, and price and of motor vehicle technology and fuel consumption in the United States. The third section considers possible U.S. regulatory developments that may affect fuel consumption and fuel tax revenue.

SUPPLY, PRICE, AND CONSUMPTION OF PETROLEUM FUELS

The future path of motor fuel prices will affect the revenues derived from established user fees because fuel prices influence travel volume, fuel economy, and the types of fuels used. Through its effect on travel volume, the price of fuel also will influence the cost of providing roads.

This section presents historical and projected price and consumption trends primarily from U.S. Department of Energy (DOE) sources: the *Annual Energy Outlook 2005* (EIA 2005a), *Annual Energy Outlook 2006 Early Release* (EIA 2005b), and *Future U.S. Highway Energy Use: A Fifty Year Perspective* (Birky et al. 2001). Each edition of the *Annual Energy Outlook* (AEO) is a 25-year projection of energy supply and consumption produced by DOE on the basis of its National Energy Modeling System and System for the Analysis of Global Energy Markets. *Highway Energy Use* is a more qualitative analysis of possible future developments in petroleum and fuels markets, highway use, and motor vehicle technology.

The AEO 2006 *Early Release* reference case projections show a slight increase in the U.S. retail gasoline price from its 2004 average of $1.90 per gallon to $2.13 in 2025 (in 2004 dollars) (Table 4-1, Figure 4-1). Comparison of this projection with DOE's 2005 and 2004 AEOs illustrates the current great uncertainty in oil market projections after 3 years of sharp price increases. DOE's 2006 reference case world oil price projection for 2025 ($48 per barrel) is 54 percent above the corresponding projection in the 2005 AEO ($31 per barrel in 2004 dollars) and the 2025 gasoline price is 31 percent higher (Table 4-1). The 2006 AEO reference case projections and assumptions are similar to the 2005 edition's "High B" world oil price case, the highest price scenario presented in that edition. DOE explains the changes as follows: "In preparing *AEO2006,* EIA reevaluated its prior expectations about world oil prices in light of the current circumstances in oil markets. Since 2000, world oil prices have risen sharply as supply has tightened, first as a result of strong demand growth in developing economies such as China and later as a result of supply constraints resulting from disruptions and inadequate investment to meet demand growth. . . . In the *AEO2006* reference case, the combined production capacity of members of the Organization of Petroleum Exporting Countries (OPEC) does not increase as much as previously projected, and consequently world oil supplies are assumed to remain tight" (EIA 2005b, 2, 4).

In the 2005 AEO edition, DOE had already raised its 2025 gasoline price projection by 12 percent in the reference case, compared with the 2004 edition, and by 37 percent in the highest world oil price projection presented. None of the AEO cases is intended to reflect consequences of petroleum supply disruptions.

DOE predicts that producers will be able to expand world oil output by nearly 40 percent and U.S. motorists will be able to increase travel by nearly 50 percent from 2003 to 2025 while the price of gasoline is maintained near $2.00 per gallon. The gasoline price will increase more slowly than the world oil price because

TABLE 4-1 Projected Growth Rates of World Oil Production, Oil and Gasoline Price, U.S. Motor Vehicle Travel, and Fuel Consumption (EIA 2005a, Tables D3, D4, D7; EIA 2005b, Tables A1, A7, A12)

	AEO 2005				AEO 2006	
	Reference Case		High B Price Case		Reference Case	
	2003–2025 Increase (%)	Annual Rate (%)	2003–2025 Increase (%)	Annual Rate (%)	2003–2025 Increase (%)	Annual Rate (%)
Gasoline price	–1	0.0	26	1.0	29	1.2
World oil price	9	0.4	73	2.5	69	2.4
Annual world oil production	51	1.9	41	1.6	39	1.5
Annual U.S. vehicle miles	57	2.1	51	1.9	48	1.8
Annual U.S. highway motor fuel consumption	51	1.9	42	1.6	39	1.5

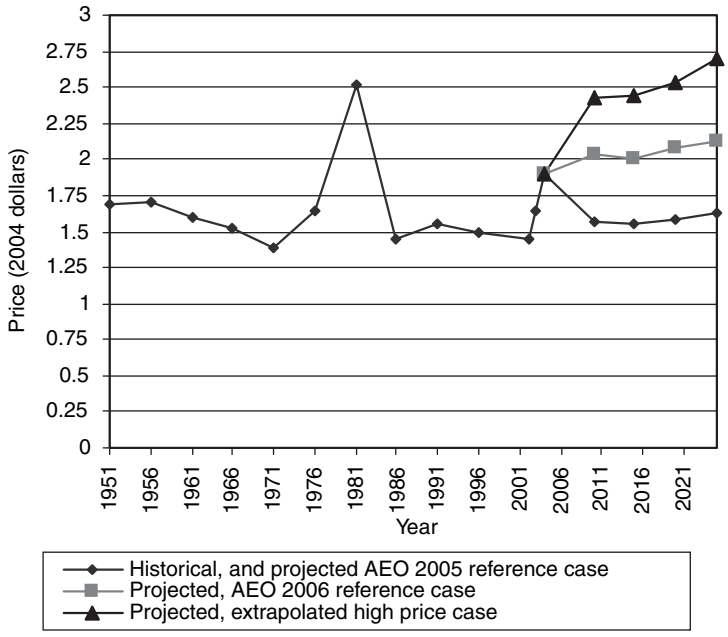

FIGURE 4-1 Gasoline prices, historical and projected, 2004–2025. (Sources: EIA 2005a, Table A12; EIA 2005b, Table A12; EIA 2005c, Table 5.24. Price deflator: BEA 2005, 48, 188, 189.)

the gasoline price includes refining and distribution costs and taxes. (DOE's gasoline price projections appear about equal to the price of the raw material plus $1 per gallon for refining, distribution, and tax.)

To suggest a range of possible future prices, Figure 4-1 shows the historical gasoline price and three projections: the AEO 2006 *Early Release* reference case (the only case presented in the *Early Release*), the AEO 2005 reference case as a low projection, and a high case constructed by multiplying the 2006 AEO reference case price by the ratio of the price in the 2005 AEO High B case to the 2005 AEO reference case price in each year. The 2025 price in this upper bound case is $2.70 per gallon, corresponding to an oil price of about $75 per barrel. (DOE points out that the oil prices in its tables until the 2006 AEO were "average refiner acquisition cost" for imported crude and that this price has typically been several dollars per barrel less than the prices of premium low-sulfur crude, which are usually reported in news stories. In the 2006 AEO, DOE has begun highlighting the premium crude prices. This chapter refers only to the average refiner acquisition cost. The $48 per barrel average refiner acquisition price projected for 2025 in the 2006 AEO corresponds to $54 per barrel for imported low-sulfur light crude.)

DOE calls its world oil price projections scenarios; that is, they are assumptions that are consistent with the available facts. Because the price of oil has been erratic in recent decades and is strongly affected by diverse political, economic, and technological factors, oil price forecasts have not been very successful. For example, the 1995 AEO projection for 2005 was $22 per barrel in the reference case and $39 per barrel (in 2005 dollars) in the high oil price case. The actual 2005 price was about $50, although the actual price during 1995–2005 usually was between the 1995 AEO reference and high projections. DOE compared its AEO 2005 projections with nine other published projections or scenarios and observed that the range between the 2005 AEO Low and High B cases spanned the range of published projections. In 2025, the range of projections reviewed was $24 to $37 per barrel (in 2003 dollars), compared with DOE's projected range of $21 to $48 per barrel (EIA 2005a, 114–115). Probably the most useful aspect of the AEO projections and other projections described below is their qualitative assessments of critical underlying factors that will influence the price of oil. In the projections the committee reviewed, the critical factors identified are that (*a*) supplies are available from multiple sources that can be developed and brought to market at lower cost than the 2005 price and (*b*) sustaining the price at too high a level would not be in the interest of producers because it would stimulate enough conservation and production from alternative sources to lower their incomes. The projections take into account rapid growth in oil consumption in China, India, and some other developing economies. For example, in DOE's 2006 reference case projection, oil consumption in China grows at over twice the world rate and China's share of world oil consumption increases from 8 percent in 2004 to 12 percent in 2025 (EIA 2005b, Table A20).

A review (Gately 2001; Gately 2004) of the DOE 2001 and 2002 projections (similar in method to the projections through AEO 2005) and of two other prominent forecasts (from the International Energy Agency's *World Energy Outlook 2000* and in the 2001 British study, *The New Economy of Oil,* by J. Mitchell et al.) with parallel results concluded that all were based on certain implausible assumptions. In particular, the projections were not derived from a behavioral model of the OPEC nations' production decisions. Instead, OPEC oil production was projected as the residual between projected demand and non-OPEC production, given an assumed price path.

Simulations presented in the review articles indicate that if OPEC is moderately effective in controlling output in its own interests and oil price increases are as moderate as DOE projected (before AEO 2006), then demand must be more responsive to price than it is in the DOE projections. The author argues that maintenance of cartel pricing will be easier in the future, in part because expanding production from OPEC oil fields will require substantial investment to develop new capacity, whereas in recent decades capacity was in excess and output could be expanded with little effort. The simulations start with ranges of assumed rates of

OPEC's target production growth (between 1 and 4 percent annually) or target market share (from 32 to 52 percent of world production; today's share is 37 percent) and use plausible ranges of elasticities and non-OPEC production costs. In the results, OPEC's revenue is not very sensitive to its rate of output expansion. The simulations indicate a likely oil price range of $24 to $36 per barrel (2000 dollars) in 2020 (Gately 2001, Figure 7; Gately 2004, Table 3), which is hardly different from most of DOE's projections before AEO 2006, but these prices correspond to lower OPEC production than DOE projected. The implication of this analysis is that the current price and DOE's latest projections are above the price that is in the long-term interest of the major producers. As DOE emphasizes in AEO 2006, a major source of supply and price uncertainty will be the willingness of producing nations to undertake investments in capacity expansion.

The DOE study *Future U.S. Highway Energy Use* (Birky et al. 2001) discusses some of the technological factors underlying projections of supply and demand elasticities. Although the report begins with disquieting observations about depletion of petroleum reserves, it concludes that petroleum supply developments, acting solely through the market, are unlikely to have decisive impact on U.S. automotive technology or travel behavior in the next several decades.

A figure in the report captioned "The World Oil Gap" shows a peak in "conventional" oil production in 2020 and a growing gap between conventional production and the extrapolated demand trend afterwards (Figure 4-2). The report observes: "The gap between continuing demand growth and declining production could be around 50 billion barrels of oil equivalent . . . by 2050, or almost twice current conventional oil production" (Birky et al. 2001, 3). Projections of the date

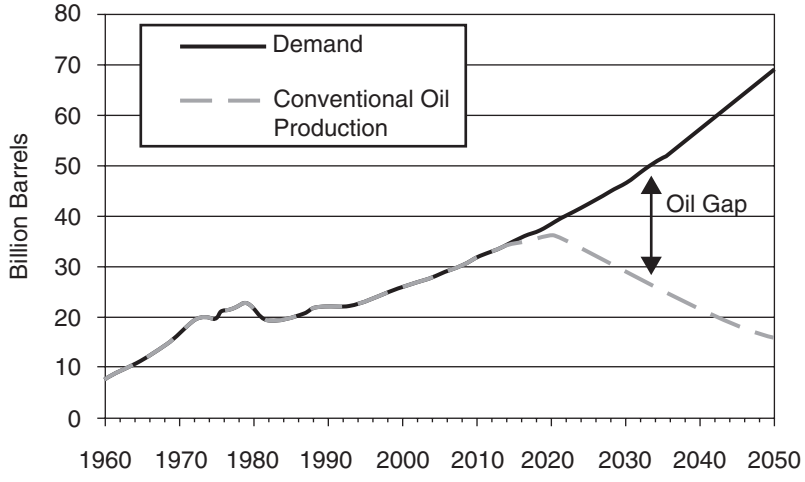

FIGURE 4-2 The world oil gap. (Source: Birky et al. 2001.)

of peak conventional oil production have received considerable exposure, for example, in the 1998 *Scientific American* article "The End of Cheap Oil," which predicted peak world conventional oil production before 2010 (Campbell and Laherrère 1998). Such predictions are derived by projecting future reserves and assuming continuation of historical relationships of reserves to production. Earlier applications of the method proved to be overly pessimistic. Projections from the 1970s were summarized in a 1979 study (Brown et al. 1979, 27):

> There are of course, basic physical constraints that will ultimately determine the level of world oil production. Projections based largely on these constraints—the reserves-to-production ratio in particular—indicate that production can increase somewhat further before peaking around 1990. [A 1979 U.S. Geological Survey study] consider[s] these ultimate production limits: "Extrapolation of historical trends in exploitation and production, together with an estimate of the stock of oil in known fields, and the assumption that the crude oil reserve-to-production ratio never drops below 10, places the date of peak world oil production before the end of 1993." And an early 1979 study by the International Energy Agency concludes "that world oil production is likely to level off sometime between 1985 and 1995."

In reality, conventional oil production expanded throughout this period (Figure 4-2).

As *Future U.S. Highway Energy Use* acknowledges, when conventional production does begin to decline, there are strong grounds for believing that the market will be capable of providing for the transition to unconventional sources without supply disruptions or any dramatic discontinuity in price. Unconventional resources that may be processed to produce liquid fuels include tar sands, oil shale, heavy oil, natural gas, and coal (Birky et al. 2001, ES-1). Supplies of unconventional resources are enormous, and production costs for some sources are less than the present world price of oil [e.g., according to the financial reports of one producer, its 2004 average operating costs (including interest, depreciation, and depletion) were CA$19.40 per barrel, or US$16.50 (Canadian Oil Sands Trust 2005, 2, 26)], although the mining and processing operations required to exploit some resources would face significant environmental constraints. DOE's *International Energy Outlook* predicts gradual development of "nonconventional production" over the next two decades, increasing from 2 percent of world oil production in 2001 to 5 percent in 2025 in the reference case and 9 percent in the high oil price case (EIA 2005d, 160–161).

Extensive development of unconventional oil resources would open the way to consumption of high-carbon fuels for the indefinite future, well after conventional oil supplies were exhausted. Therefore, policies aimed at controlling greenhouse gas emissions may eventually block or supersede development of these resources (Grubb 1998).

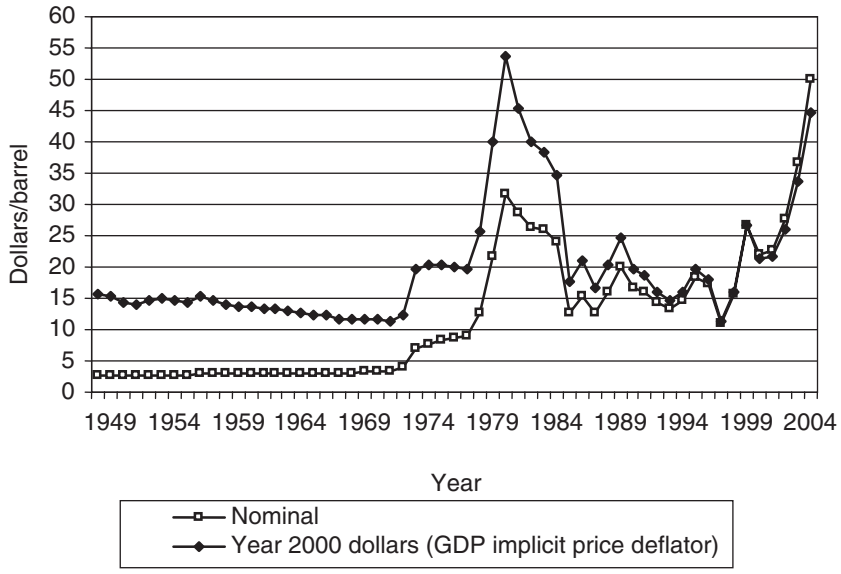

FIGURE 4-3 Crude oil domestic first purchase prices, 1949–2005. Point for 2005 is June price. (Sources: EIA 2004a, Table 5.18; EIA 2004b, Table 1; EIA 2005e, Table 9.4.)

The history of oil prices since the energy crisis of the 1970s has been volatile (Figure 4-3). None of the projections reviewed explicitly considers the impact of more volatile prices on future fuel economy. Even if the long-run track of average oil price follows a moderate path, more frequent and extreme price spikes in the future may stimulate purchases of high-mpg or alternative-fuel vehicles, although the historical evidence suggests that the magnitude of this effect may not be great.

MOTOR VEHICLE TECHNOLOGY PROJECTIONS AND FUEL TAX REVENUE

Because of the importance of the fuel tax in financing highway programs, highway agencies are interested in projections of fuel economy and motor vehicle technological developments. Improvement in fuel economy would create pressure for the federal government and the states to raise fuel tax rates or curtail highway spending. In addition, in the absence of changes in the user fee system, expansion of use of vehicles that do not consume taxed liquid fuels (e.g., battery-powered electric vehicles) would reduce revenues, and the states anticipate that lawmakers will consider promoting introduction of alternative fuels and technology through highway user tax breaks such as the break gasohol received until 2005. As an aid in assess-

ing whether these concerns are warranted, this section summarizes technology projections from five sources:

- DOE's *Annual Energy Outlook* (EIA 2005a; EIA 2005b)—the reference case and the high technology case from AEO 2005 and the reference case from the AEO 2006 *Early Release.* The fuel economy improvement by 2025 in the AEO 2006 reference case [with 2025 gasoline price at $2.13 per gallon (in 2004 dollars) compared with $1.63 per gallon in the earlier edition] is similar to the improvement in the high technology case of AEO 2005. The three cases are presented to indicate the sensitivity of DOE's mpg projections to fuel price and technology assumptions.
- A 2002 National Research Council (NRC) study of feasibility and costs of improvements in fuel economy for various classes of vehicles (NRC 2002).
- A National Cooperative Highway Research Program (NCHRP) study that projected the effect of possible future fuel economy improvements and increased use of alternative fuels on Federal Highway Trust Fund revenue (Cambridge Systematics 2003).
- A California Air Resources Board (CARB) analysis supporting its proposal for regulations requiring reductions in carbon dioxide emissions by vehicles sold in California beginning in 2009 (CARB 2004).
- The DOE *Future U.S. Highway Energy Use* study described above (Birky et al. 2001).

These studies are described in Appendix B, along with two other studies of future automotive energy efficiency: a report on global automotive energy consumption of the Sustainable Mobility Project by the World Business Council for Sustainable Development (SMP 2004) and a 2004 NRC study of prospects for hydrogen-fueled vehicles (NRC 2004).

Table 4-2 shows fuel economy projections or scenarios from the five studies. With the exception of the AEO reference cases, the projected fuel efficiencies are not technology forecasts. Rather, they specify technology exogenously, consistent with stated criteria relating to cost, vehicle performance requirements, and technological feasibility. The mpg values are the researchers' estimates of fuel economy improvements that might reasonably be expected as the consequence of new regulations or increases in the price of fuel.

The NRC and CARB scenarios are intended to represent fuel economy improvements that would be cost-free to drivers: they would not involve general downsizing of vehicles or degrade performance, and the capital and operating costs of the technology improvements would be paid for by fuel savings. Such assessments of feasibility are controversial. For example, the motor vehicle industry claims that the initial cost of the CARB projected technology package to new car

TABLE 4-2 Automotive Technology Projections and Scenarios

Source	Assumptions	Projection Year	Projected ldv mpg			Percent Reduction in gpm Versus 2003[f]	
			New Vehicle: EPA	New Vehicle: On-Road[a]	Fleet	New Vehicle	Fleet
DOE AEO 2006 *Early Release* reference case	Greater sales of hybrid and diesel vehicles than in 2005 reference case (14% of 2025 sales).	2025	28.8	25.0	22.0	13	9
DOE AEO 2005 reference case	19% of ldv sales in 2025 are advanced technology (including HEV) or alternative fuels. 80% of advanced technology sales are result of regulation. 2025 new car hp 26% above 2003.	2025	26.9	23.4	21.0	7	5
DOE AEO 2005 high-technology case	Lower cost, greater efficiency gains, and earlier introduction for advanced technology than in reference case.	2025	28.8	25.0	22.1	13	10
NRC 2002 average case	Technologies adopted would yield fuel savings covering purchase price for constant vehicle size and performance and could be in production by 2015.[b]	2015	29.8	25.9		16	

NRC 2002 low-cost/high-mpg case	As in average case, but optimistic assumptions regarding cost and effectiveness of technological improvements.[b]	2015	32.1	27.9		22	
NRC 2002 high-cost/low-mpg case	As in average case, but pessimistic assumptions.[b]	2015	27.4	23.8		8	
NCHRP (Cambridge Systematics 2003)	NRC 2002 fuel economy projections become regulatory requirements in 2015; phase-in starts 2006; vmt by size class and model year projections as in AEO 2002 reference case.[c]	2020			23.2		14
CARB 2004	Technologies adopted would yield fuel savings covering purchase price for constant vehicle size and performance and could be phased into production between 2009 and 2014.	2020			23.4	28	15
CARB 2004	As above.	2030			26.4	28	24
Birky et al. 2001 enhanced conventional vehicles strategy	Conventional IC engines with incremental technology improvements—weight reduction, engine/transmission enhancements, aerodynamics—as might be driven by high fuel prices.[d]	2050	33.7	29.3		26	
Birky et al. 2001 HEV/FCV hydrogen strategy	New vehicle market 70% hybrid electric, 30% hydrogen fuel cell by 2040.[d, e]	2050	41.0	35.6	35.6	39	44

(*continued on next page*)

TABLE 4-2 (*continued*) **Automotive Technology Projections and Scenarios**

[a] On-road mpg is calculated as (EPA mpg)/1.15, on the basis of the approximate conversion factor reported in NRC 2002, Table 4-1.

[b] The study reports mpg projections by vehicle size class, but not for the vehicle fleet. The fleet averages shown in the table are the average of the size class projections weighted by model year 2004 estimated market shares by size class from NHTSA 2003.

[c] The study reports projected fuel consumption rather than mpg. The mpg values in the table are derived from projections of fuel consumption and vmt.

[d] The study reports percentage changes in mpg but does not state the base year mpg. Mpg values in the table assume base year mpg values are values for 2000 in AEO 2002.

[e] This scenario involves hydrogen fuel cell vehicles. The mpg values in the table are the values that would produce the equivalent reduction in fuel energy consumption in a liquid fuel–powered fleet.

[f] Percentage reductions are with respect to 2003 U.S. average light-duty vehicle fuel economy according to AEO 2005: 20.0 mpg fleet, 25.1 mpg new vehicle EPA.

Abbreviations:

ldv: light-duty vehicle
mpg: miles per gallon
gpm: gallons per mile
HEV: hybrid electric vehicle
FCV: fuel cell vehicle
IC: internal combustion
DOE: Department of Energy
NRC: National Research Council
AEO: *Annual Energy Outlook*
vmt: vehicle miles traveled

buyers would be three times the state's estimate (Hall 2004). The higher the cost (in vehicle purchase price or performance degradation) to motor vehicle owners, the less demanding regulatory efficiency standards are likely to be.

Taken together, the projections suggest that fuel economy improvements of 15 to 25 percent (i.e., an average decrease of 15 to 25 percent in fuel consumption per mile) for new light-duty vehicles would be practical within the next 10 to 20 years, without the need for technical breakthroughs and without downsizing or vehicle price increases that would seriously affect the vehicle market or driving habits. If such new-vehicle efficiency improvements were attained, the improvement in light-duty vehicle fleet fuel economy would be 10 to 20 percent by 2025, according to the projections. As noted, these are not projections of likely outcomes, but rather of fuel economy gains that could reasonably be expected if forced by regulation or fuel prices.

None of the projections foresees important use of vehicles not powered by gasoline, diesel, or ethanol blends before 2025. For example, they do not project significant market shares for hydrogen-fueled cars or electric vehicles with batteries charged from electric power lines. Thus, vehicles foreseen to be in use in 2025 will be subject to existing fuel taxes.

The three studies reviewed that consider the connection between fuel price and the motor vehicle market (EIA2005a, 62; SMP 2004, 104–105; Birky et al. 2001, 9) all conclude that no likely fuel price increase or technology development in the period to 2025 will have a dramatic market effect on fleet average fuel economy by 2025. (The NRC, CARB, and Birky et al. projections and scenarios summarized in Table 4-2 are assessments of possible improvements in fuel economy based on the assumption that the regulatory or market forces required to induce them are present; they are not forecasts of likely outcomes.) This is partly because present regulations elevated fuel economy above the level that would have prevailed at historical fuel prices in an unregulated market. In addition, during periods of stable fuel prices, consumers have shown a preference for taking advantage of efficiency improvement technology by buying larger, higher-performance vehicles rather than by reducing their dollars-per-mile operating costs. The implication of the projections in these three studies is that if fundamental changes in fuel economy, fuel price, or engine technology occur in the next several decades, they are more likely to be the result of government intervention than energy market developments.

After 2025, projections are essentially speculative, but if the rate of fuel economy improvement projected to 2025 in the AEO 2006 reference case were to continue for another 20 years, light-duty vehicle fleet fuel economy would be 24.5 mpg (an 18 per cent reduction in fuel consumption per mile compared with today). This fleet fuel economy is not inconsistent with the projection in the Enhanced Conventional Vehicles scenario in *Future U.S. Highway Energy Use* of new vehicle EPA fuel economy rating of 33.7 mpg in 2050 (equivalent to

new-vehicle on-road fuel economy of about 29.3 mpg) (see Table 4-2). According to the HEV/FCV (hybrid electric vehicle/fuel cell vehicle) Hydrogen scenario in *Future U.S. Highway Energy Use,* a complete conversion of new vehicle sales to a mix of hybrid electric vehicles and vehicles powered by fuel cells consuming hydrogen could occur by 2040. In this scenario, vehicle energy consumption per mile would be reduced by more than half by 2050 compared with today, and the reduction in consumption of traditional liquid fuels would be even greater (see the last line in Table 4-2). Hybrid electric vehicles combine an internal combustion engine with an electric motor powered by batteries (charged by the internal combustion engine or by energy captured during braking) in order to gain energy efficiency. A fuel cell is a kind of battery that consumes hydrogen or another fuel to produce an electric current (without combustion or a mechanical generator). The current powers an electric motor that propels the vehicle.

Truck Fuel Economy Trends

Twenty-three percent of all federal and state fuel tax revenue is from taxes on diesel fuel, nearly all of which is consumed by large, freight-carrying trucks (FHWA 2003b, Tables MF-121T, MF-27). Therefore, truck fuel economy trends are important for transportation program revenue. Large trucks have made substantial fuel economy gains in recent decades, but more stringent emissions regulations may retard future fuel economy improvements (DOE 2003). The 2006 AEO reference case projects a 9 percent reduction in fuel consumption per mile for the freight truck fleet by 2025 (to 6.6 mpg, from 6.0 in 2003) (EIA 2005b). The 2005 AEO also projected a 9 percent reduction in the reference case and a 10 percent reduction in fuel consumption per mile in the high technology case (EIA 2005a, Table A.7, p. 86).

Freight truck shares of highway vehicle miles and highway fuel consumption in 2003 and the AEO 2006 projections of 2025 shares are as follows:

	2003	2025
Share of vehicle miles (percent)	7.5	8.6
Share of fuel consumption (energy units, percent)	21.2	23.4

DOE projects that annual vehicle miles of freight truck travel will grow 70 percent over the period. Freight trucks' share of fuel consumed is projected to grow more slowly then their share of travel because projected fuel economy improvements are greater than for light-duty vehicles. If these projections are realized, trucking's contribution to user fee revenues relative to its share of travel will decline unless legislatures make larger adjustments in truck tax rates than in rates affecting light vehicles.

Fuel Tax Revenue Implications

Developments in motor vehicle fuel economy and propulsion technology could affect the viability of the present transportation finance scheme in three ways. First, maintaining constant revenue per vehicle mile would require raising cents-per-gallon fuel tax rates if average fuel economy improves. Second, some technologies (e.g., electric and hydrogen-powered vehicles) do not consume the fuels that are now within the highway user tax scheme. Finally, lawmakers may decide to provide incentives for adoption of new technologies in the form of lower user fee payments (for example, the lower federal excise tax rate paid on gasohol than on gasoline before 2005).

The projections of fleet fuel economy percentage improvement in the last column of Table 4-2 indicate the magnitude of fuel tax rate increases that would be necessary to compensate for fuel economy improvements. Maintaining constant revenue per vehicle mile is a reasonable benchmark for judging fiscal impact, since, as Figure 2-1 shows, revenue has been fairly constant at around $0.035 per mile for the past 25 years. Maintaining constant revenue per vehicle mile after a 15 percent reduction in the fleet average fuel consumption per mile (i.e., a midpoint projection for 2025 from among the various optimistic technology scenarios summarized in Table 4-2) would require a 17.6 percent [100(0.15/0.85)] increase in the constant-dollar fuel excise tax rate. With such an increase, the 2003 combined federal and state tax rate on gasoline of $0.375 per gallon would rise to $0.441 per gallon. The fuel tax produces about 65 percent of all highway user revenues (see Table 2-2), about equal to half of all highway spending, so the revenue loss from an uncompensated 15 percent fuel economy improvement (assuming travel and vehicle sales were unaffected) would equal 10 percent of prior user fee revenues and 8 percent of spending.

The NCHRP study (Cambridge Systematics 2003) projected the effect on trust fund revenues of a range of alternative future tightenings of federal new-vehicle fuel economy standards, from a modest increase in the required fuel economy of new light trucks to a 50 percent increase in the required mpg for all vehicle classes compared with present legal standards. The projections were constructed to be consistent with the DOE AEO projections of travel by vehicle size class. In all cases, new-vehicle fuel economy standards are assumed to ramp up linearly from their present values in 2006 to their maximum values in 2015. One case assumes that the new standards are based on the estimates in the 2002 NRC study of cost-efficient improvements in fuel economy for each class of light-duty vehicle. (Table 4-2 shows the projected average new-vehicle fuel economy from the NRC study and the NCHRP study's estimated fleet fuel economy.) The NCHRP authors argue that the NRC estimates or similar ones would be the most reasonable guide available to Congress if it were to decide soon to enact new fuel economy standards. The authors project that imposition of these standards would reduce light-duty vehicle fuel consumption by 9 percent in 2020 compared

with the AEO 2004 reference case and that Federal Highway Trust Fund revenue in 2020 would be reduced by $3 billion (7 percent). The federal revenue reduction in 2020 could be avoided by a $0.0125-per-gallon increase (in 2002 dollars) in the federal fuel tax.

The NCHRP study does not project revenues beyond 2020. The impact in later years would be greater, since the turnover of the fleet to higher-efficiency vehicles would not be complete in 2020. When turnover was complete (by 2025 or 2030), the revenue impact would be around 14 percent of trust fund revenues compared with revenues under the assumptions of the AEO reference case.

The NCHRP study also projects the revenue impact of continuation of the pre-2005 federal gasohol tax policy and of hypothetical additional federal measures to promote gasohol. Legislation enacted in 2004 raised the gasohol excise tax rate to equal the gasoline rate and provided that all revenue from the tax be credited to the Highway Trust Fund. This eliminated the prior trust fund revenue loss. However, the NCHRP study's projections illustrate how pollution abatement and conservation incentives could have an important effect on user fee revenue. As Chapter 2 noted, if the federal excise tax on gasohol had been the same as for gasoline and credited to the trust fund, trust fund revenue would have been about $1.6 billion per year greater in 2002. Gasohol consumption was 21 billion gallons in 2002, 12.5 percent of all highway motor fuel use (FHWA 2003b, Tables MF-21, MF-33E). The NCHRP study considered the impact of legislation, proposed in Congress in 2003 but not enacted, that would have mandated increased production of renewable fuels and replacement of a common fuel additive (methyl tertiary butyl ether, which is added to fuel as an octane enhancer to comply with federal air pollution regulations) with ethanol. Enactment of these proposals would have increased the trust fund revenue loss to $3.9 billion per year by 2010 and beyond (a 12 percent reduction) (Cambridge Systematics 2003, Table 2).

Changes in motor vehicle technology would also affect state tax revenue. For example, in California, where the legislature has mandated reduction of greenhouse gas emissions by motor vehicles, gasoline excise tax revenues dedicated to highways accounted for 54 percent of state-collected revenues devoted to highways in 2002 (including revenues provided for state spending and for state grants to local government, but excluding federal grant payments received) (FHWA 2003b, Table SF-1). There are no local gasoline excises in the state. Gasoline sales correspond approximately to the tax base that would be affected by the light-duty vehicle CO_2 emissions standards proposed by CARB to meet the legislature's mandate (neglecting the small amounts of gasoline consumed by larger vehicles and of diesel consumed by light vehicles) (CARB 2004). Therefore, a 25 percent reduction in light-duty vehicle fuel consumption per mile (which CARB proposes as a target for 2030; see Table 4-2) would have reduced revenues available for highways in 2002 by 13.5 percent. An increase in the state gasoline tax from the pres-

ent rate of $0.18 per gallon to $0.24 per gallon (in 2002 dollars) would be necessary to make up the shortfall. The state's gasoline tax was last increased in 1994 and is below the 2002 national average of $0.191 per gallon. Thirteen states had rates of $0.24 per gallon or higher in 2002 (FHWA 2003b, Table MF-121T). Thus, maintaining fuel tax revenue while implementing the proposed standard would not require tax rates of unprecedented magnitude compared with other states (although in California, the legislature has not changed the motor fuel tax rate since 1994).

Motor vehicle purchase price increases, operating cost decreases, or performance degradation caused by new regulations will affect excise tax revenues by affecting the volume of highway travel and vehicle sales as well as fuel consumption per mile of travel. Changes in highway travel also would affect highway maintenance and construction costs and might be accompanied by changes in transit use, fare revenue, and costs. None of the studies reviewed attempted to trace through all these fiscal effects fully. In the case of fuel economy improvements driven by regulation, the projections suggest that the dominant impact would be the effect of improved fuel economy on fuel sales, because it is assumed (in the NRC, CARB, and DOE projections) that the initial cost to vehicle buyers of the changes in technology introduced are largely offset by fuel cost savings.

If fuel economy improvements are driven by higher fuel prices, the revenue effect of reduced travel might be important. For example, in the 2005 AEO High B oil price case (in which the 2025 world oil price is 58 percent higher than in the reference case), 2025 motor vehicle fuel consumption is 6 percent lower than in the reference case and travel is 4 percent lower. That is, more than half of the reduction in consumption is the result of reduced travel rather than improved fuel economy (EIA 2005a, Tables C1, C7). Contrary to this projection, most studies show that half or more of the long-term reduction in fuel consumption that results from a fuel price increase is the result of improvement in fuel economy rather than of reduction in vehicle miles of travel, although the reduction in travel is not insignificant (Parry 2002, 30; Hanly et al. 2002, 3).

Summary

The projections reviewed suggest that a 10 to 20 percent reduction in average gallons of fuel consumed per mile by the light-duty vehicle fleet is possible by 2025 if fuel economy improvement is driven by new government intervention such as an increase in the corporate average fuel economy (CAFE) standards in federal law or by sustained high fuel prices. In the absence of such pressures, fuel economy improvement is likely to be no more than a few percent. Maintaining constant revenue per vehicle mile after a 15 percent decrease in gallons per mile would require a 17.6 percent increase in the combined average federal and state gasoline tax rate, about $0.07 per gallon (in 2002 dollars), or increases in other user fees.

If fuel price increases in this period are great enough to drive significant fuel economy improvements, revenue would be affected by reduced travel (compared with future travel volume if fuel price followed the historical trend) as well as by reduced fuel consumption per mile of travel. Reduced travel would also affect transportation agencies' costs.

After 2025, technology and market projections become even more speculative. However, all the studies reviewed conclude that government intervention or high fuel prices could bring about large market shares for hybrid electric and fuel cell–powered vehicles and consequently much greater reductions in gasoline consumption.

The assessment of the prospects for fuel economy improvement presented here is not dependent on the realization of optimistic fuel price forecasts. In the two sets of projections from the 2005 AEO shown in Table 4-1, the world oil price in the High B case is 58 percent higher in 2025 than in the reference case, resulting in a 27 percent higher gasoline price and 6 percent lower motor vehicle fuel consumption (i.e., a 0.1 percent reduction in 2025 fuel consumption for each 1 percent increase in the 2025 world oil price). Suppose the price sensitivity implied by these projections were doubled, and the 2025 oil price reached $76 per barrel (the price consistent with the extrapolated high oil price case shown in Figure 4-1). Then the projected reduction in fuel consumption would be 29 percent (i.e., a 143 percent price increase compared with the 2005 AEO 2025 reference case projection times a reduction in fuel consumption of 0.2 percent for each 1 percent increase in oil price). This is the same order of magnitude as the mpg improvement in the technology-driven or regulation-driven fuel economy improvement scenarios shown in Table 4-2.

These two effects—mpg improvement driven by prices and improvement driven by regulation—are not additive. If regulations require fuel economy improvements beyond what the market would generate at a given fuel price, the fuel price must first rise to the level at which the market would demand the regulatory mpg before price can have much further effect on fuel economy. Therefore, the conclusion that 20 percent is the likely economy improvement that can be expected by 2025 in response to effective regulation or sustained high fuel prices is consistent with greater price sensitivity and higher future world oil prices than DOE's projections show.

POSSIBLE REGULATORY DEVELOPMENTS

The studies reviewed in the previous section that projected likely or possible fuel economy trends all concluded that regulation or other forms of government intervention, rather than the world market price of petroleum, will be the main driving force toward improved motor vehicle fuel economy in the next two decades. These conclusions were derived from two observations. First, resource stocks

appear ample to prevent more than moderate sustained petroleum price increases in the next 20 years. Second, consumers have chosen, over the past 20 years (when fuel prices were not rising), to take advantage of technological advances in fuel economy by purchasing larger vehicles and vehicles with improved performance rather than by reducing their spending on fuel. Of course, if consumers in the next few decades are confronted with persistently rising fuel prices, they might decide to utilize technological advances to maintain performance and fuel expenditure, with declining volume purchases of fuel.

Because of the potential impact of fuel economy improvement on fuel tax revenue and transportation program funding, an examination of the possible forms of future government interventions that could spur changes in motor vehicle fuel economy, the likelihood of interventions, and the events that might motivate them is relevant to the committee's task. The possible actions that have received serious public consideration can be divided into two categories: motor vehicle performance standards (fuel economy and emissions standards) and economic incentives.

Motor Vehicle Standards

Since 1978, federal law has required that the average fuel economy of all the light-duty vehicles sold by each vehicle manufacturer in a year not fall below specified fuel economy standards. The standards in 2005 were 27.5 mpg for automobiles and 21.0 mpg for light trucks (which category includes SUVs), as measured in a test defined by the Environmental Protection Agency. These EPA mpg values are about 15 percent higher than actual on-road mpg (NRC 2002, 8). The NRC evaluation of CAFE standards (NRC 2002) states the apparent consensus view that the standards contributed to the fuel economy improvement of U.S. light-duty vehicles since 1970, reinforcing the effect of high fuel prices in the 1970s, and that the standards prevented fuel economy from declining in the 1980s and 1990s, when fuel prices were falling or constant (Figure 4-4).

The NCHRP study concluded that promulgation of more stringent federal fuel economy standards within a decade is a "medium-probability" event (Cambridge Systematics 2003, 14–16, 24). In support of this conclusion, the study cited recent action by the U.S. Department of Transportation (USDOT), which has authority to adjust light truck CAFE standards without congressional action, to raise the light truck fuel economy standard (to 22.2 mpg by 2007) as well as recent interest in Congress in raising the standards for cars. From 1996 to 2001, Congress blocked USDOT from spending funds to develop new CAFE standards. This restriction has been discontinued, and proposals to review CAFE standards were presented during discussions of energy legislation in Congress in 2003 and 2004 (Bamberger 2004). The recent oil price increase and the California greenhouse gas emissions control legislation might be taken as indications that more stringent federal fuel economy standards are within the realm of possibility.

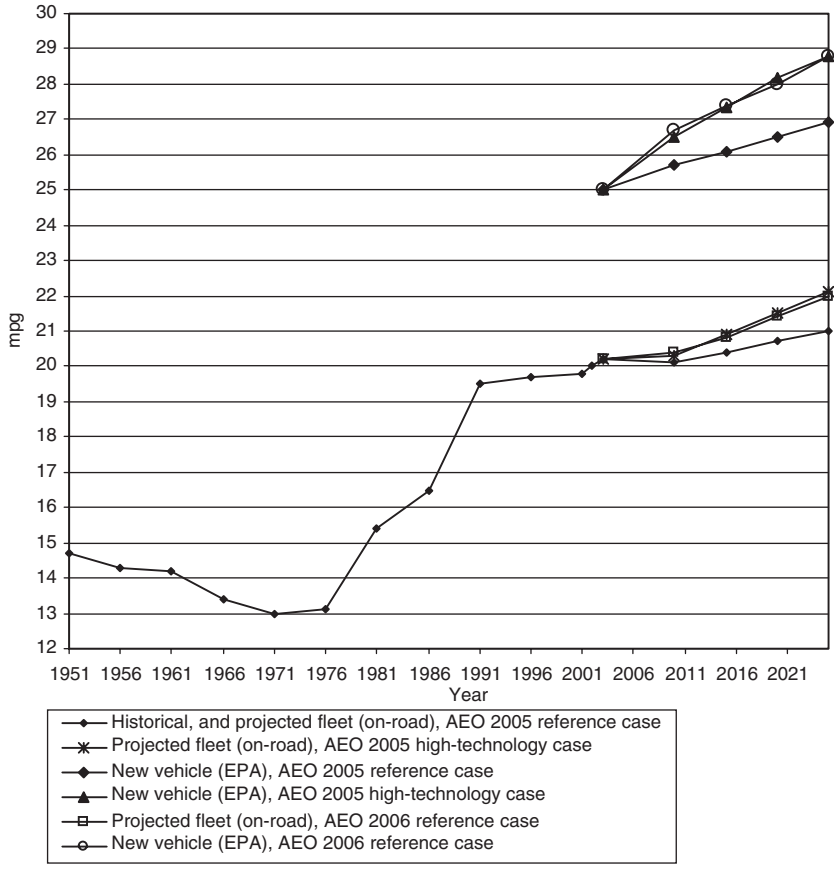

FIGURE 4-4 Light-duty vehicle fuel efficiency, historical and projected, 2003–2025. (Sources: EIA 2005a; EIA 2005b.)

The NCHRP study, noting the initial market success of certain high-efficiency vehicles like the Toyota Prius and recent motor vehicle manufacturer announcements of voluntary plans to improve the fuel economy of SUVs and light trucks, concluded that voluntary industry action to improve fuel economy is a high-probability event in the next decade. The industry's involvement in the FreedomCAR cooperative research program with DOE is a further suggestion that it may feel pressure to produce improvements in fuel economy beyond those that normal market considerations might dictate, perhaps in order to forestall tightening of mandatory standards.

New standards for motor vehicle pollutant emissions would also affect fuel economy. As the CARB proposal illustrates, regulations for reducing greenhouse gas emissions of vehicles burning petroleum-derived fuels have the same effect

as fuel economy standards because emissions of the main greenhouse gas, CO_2, are proportional to fuel consumption.

Measures to reduce other motor vehicle pollutant emissions (including oxides of nitrogen and particulates) can conflict with the goal of improving fuel economy. The most important effect of this conflict may be to deter use of diesel engines (which have an efficiency advantage over gasoline engines) in light-duty vehicles and to slow fuel economy improvements for diesel trucks (GAO 2000, 16). Emissions regulations that necessitate special fuel formulations may increase the cost of fuel and thereby reduce consumption.

Concern about the safety of lighter, smaller vehicles may constrain enactment of more stringent fuel economy standards, although the actual effect of actions to improve fuel economy on safety is a subject of controversy (NRC 2002, 77, 117–124).

Eventually, the nation may decide that it is necessary to mandate conversion to vehicles that use no petroleum fuel: battery-powered electric cars (charged by electricity from the electric power grid), hydrogen-powered cars, or cars burning biomass fuels. However, the technology projections presented in the preceding section agree in predicting no early widespread introduction of hydrogen or electric vehicles because of the costs involved. If the policy objective is to reduce greenhouse gas emissions, economic considerations may argue against government intervention to promote early introduction of these vehicles, because the initial measures taken to reduce greenhouse gas emissions should be the cheapest. More cost-effective measures exist, especially CO_2 reduction from power plants. One study has estimated that, if a target of stabilizing the CO_2 atmospheric concentration at double the preindustrial level were set, then the least-cost schedule of technological changes would not involve substantial introduction of non-CO_2-generating vehicles before 2040 (Keith and Farrell 2003). The study assumed that the costs of hydrogen-fueled vehicles would remain high. If technological advances yield cost reductions, earlier introduction of hydrogen-fueled vehicles would become cost-effective. The NRC hydrogen fuels study described in Appendix B contains an example of such an optimistic hydrogen scenario (NRC 2004).

An innovative approach to regulating fuel economy, the "cap and trade" program under which vehicle manufacturers would be allocated fuel consumption quotas or credits for their new vehicles that they could trade among themselves (CBO 2003), has not attracted legislative interest. However, enactment of such a program could accelerate fuel economy gains because the cost of attaining a specified degree of improvement would be reduced.

Incentives

Incentives of numerous kinds are in effect or have been proposed to promote development and sale of high-mpg, low-emission, or alternative-fuel vehicles or to

otherwise encourage conservation or reduce driving. Such incentives may affect transportation finance by reducing fuel tax revenue. Possibly more significantly, incentives that involve forgiveness of highway user fees (for example, the present tax treatment of gasohol) or imposition of additional fees on some highway users may entail conflicts that affect the viability of present transportation revenue arrangements. Of course, the occurrence of a negative impact on revenue dedicated to transportation is not in itself relevant to the merits of these policies. However, the possible tax revenue side effects should be recognized when incentive programs are enacted and consideration given to the need to replace lost revenue.

Existing federal incentive programs include the following:

- Tax treatment of gasohol: As an incentive to use alternative fuels and to aid farmers and ethanol producers, the federal excise tax on gasohol is $0.053 per gallon less than the tax on gasoline sold as motor fuel. (As of 2005, the revenue impact of this subsidy affects the general fund; the Highway Trust Fund receives revenue as if the gasohol tax were the same as the gasoline tax.)
- Tax incentives for HEVs and electric vehicles: Purchasers of electric vehicles are entitled to a tax credit equal to 10 percent of the purchase price. Purchasers of new HEVs in 2005 could claim a $2,000 deduction on their federal income tax returns (Unites State Code, Title 26, Section 179a). The deduction will be replaced by new tax credits in 2006.
- Gas guzzler tax: Buyers of new passenger cars (but not SUVs or light trucks) that have fuel economy poorer than 22 mpg in the EPA test must pay a federal tax of $1,000 to $7,700, depending on mpg. The NRC CAFE standards study concluded that this tax has influenced vehicle design and sales (effectively establishing a floor of 22 mpg for new vehicles), although today fewer than 1 percent of new cars are subject to the tax (NRC 2002, 21).
- CAFE credits for alternative fuels: Motor vehicle manufacturers who sell vehicles that can be operated on ethanol or natural gas earn credits that allow them to have an actual average mpg for the vehicles they sell that is lower than the CAFE standard (NHTSA 2004).

At least 14 states offer incentives to ownership of HEVs or other alternative-technology vehicles. Incentives include exemption from all or part of state sales or excise taxes on the purchase price of the vehicle, use of high-occupancy vehicle lanes by single-occupant vehicles, or income tax deductions or credits for some part of the purchase price (Hybridcars.com 2004). With the exception of free parking offered in some California localities, none of these measures appears to affect dedicated transportation revenues directly or to exempt vehicle owners from paying customary user fees.

Allowing multioccupant vehicles to use toll lanes for free or at a lower toll than single-occupant vehicles might be viewed as forgiveness of a road user fee as a con-

servation incentive. Only four such high-occupancy/toll (HOT) lanes were in operation in the United States in 2005. They are tolled lanes parallel to freeways and offering free use or lower tolls to carpoolers (FHWA 2003a, 5). However, the HOT lanes concept is attracting interest among the states, and the federal surface transportation program reauthorization bills in Congress would promote HOT lane projects (as will be described in Chapter 5).

Imposition of energy or carbon taxes is prominent among proposals for new forms of incentives to reduce energy consumption or CO_2 emissions. A broadly based energy tax or tax on fossil fuel could achieve a specified reduction at lower total cost than rationing measures or consumption standards targeted at one consuming sector (for example, the CAFE standards) because producers and consumers would have flexibility to reduce consumption and emissions in ways that had the least cost to them. A Btu tax on all fuels (coal, natural gas, petroleum, hydropower, and nuclear power) was proposed by the Clinton administration and passed by the House in 1993 but was not approved by the Senate (McElveen 1993). The goals were conservation as well as revenue raising. The measure that eventually was enacted later in 1993 imposed new excise taxes on transportation fuels only, including the $0.043 deficit reduction tax on gasoline, designated for deposit to the general fund rather than to the Highway Trust Fund. Four years later, Congress directed that the $0.043 henceforth be deposited in the trust fund.

Imposition of new fuel taxes is sometimes proposed as a way to internalize the costs of pollutants other than CO_2 (oxides of nitrogen, particulates, and hydrocarbons). Unlike CO_2 emissions, which are nearly proportional to fuel use, emissions of these pollutants vary greatly depending on vehicle characteristics, traffic, road conditions, and driving habits; the health impacts of emissions depend on the location. Similarly, a fuel tax has been proposed as a way to internalize congestion and accident costs that an individual vehicle operator imposes on other road users. Congestion and accident costs also vary greatly depending on conditions. A fuel tax is an imperfect instrument for these purposes since it fails to provide a strong incentive to the worst offenders to change their behavior and at the same time penalizes vehicle operators who are imposing relatively small costs on others. Nonetheless, such taxes have been advocated as second-best measures that are justified in light of the cost and technical problems of real-time observation of the emissions or congestion costs caused by an individual vehicle (Harrington and McConnell 2003, 46–49; Parry 2002; Parry and Small 2002). There appears to be little political interest in such taxes, and technological barriers to more effective forms of congestion and emissions taxes are falling. Therefore, enactment of such taxes in the near future seems unlikely.

Summary

It is impossible to forecast regulations, but the extent of recent interest in such measures suggests that enactment of new CAFE standards over the next decade

and new federal and state incentives to promote conservation and alternative fuels are possibilities. Transportation agencies ought to be prepared to contribute to the development of such programs with analyses of the revenue impacts on transportation programs and proposals for measures to maintain intended revenues as regulations are enacted. Such measures could include increasing fuel tax rates or the rates of other dedicated user fees to compensate.

Regardless of the market share that alternative propulsion systems achieve in the next 20 years, governments must address the question of how users of these vehicles should be charged for road use. To ensure that users of alternative-fuel vehicles pay an appropriate share of the cost of transportation facilities, enactment of new taxes (for example, special excise taxes on vehicles or on components like batteries) may be required.

Incentives and other policies to promote conservation or reduce pollutant emissions could be made more cost-effective, and at the same time impacts on transportation program revenues would be lessened, if they were broadly targeted. A tax levied on all fuel consumers (or on all polluters) will attain a specified objective at a lower cost than a tax or restriction targeting only transportation. An incentive that subsidizes road use by forgiving payment of highway user fees can unnecessarily increase the cost of meeting the conservation or emissions goal by encouraging inefficient use of roads. For example, promoting the purchase of high-mpg vehicles by a cash subsidy may have lower public cost than using free admission to toll lanes as an inducement.

The history of the 1993 Btu tax proposal suggests the conflicts that may emerge between the practice of imposing fuel taxes for conservation or pollution reduction purposes and the practice of collecting highway user fees in the form of fuel taxes. Replacing or supplementing the fuel tax with more direct forms of user fees like mileage charges would reduce, if not eliminate, the potential for friction between transportation finance and programs to promote conservation and emissions reductions.

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Abbreviations

BEA	Bureau of Economic Analysis
CARB	California Air Resources Board
CBO	Congressional Budget Office
DOE	U.S. Department of Energy
EIA	Energy Information Administration
FHWA	Federal Highway Administration

GAO	General Accounting Office
NHTSA	National Highway Traffic Safety Administration
NRC	National Research Council
SMP	Sustainable Mobility Project

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Finance Reform Proposals

Toll Road Expansion and Road Use Metering

This chapter and Chapter 6 review proposals for changes in revenue sources and other financing arrangements for highways and transit in the United States. The proposals are diverse and from a variety of sources, and they have been useful resources to the committee in forming its conclusions. The proposals are also valuable because they shed light on the nature of the finance problems confronting transportation agencies that have motivated calls for reform.

The diversity of reform proposals reflects different points of view on how the underlying problems of transportation finance should be defined. The proposals all recognize, to some extent, dual goals of finance policy: to assemble a collection of revenue flows adequate to support a desired level of spending and to establish practices that promote investment in high-return projects and efficient operation of existing facilities. The starting point of proposals from government sources and transportation interest groups tends to be spending needs (generally seen as greater than present revenues can support). Proposals from academia and other independent sources tend to emphasize the importance of finance practices that provide incentives for better spending and operating decisions and usually avoid judgments on the proper levels of revenue and taxes.

Each of the proposals described in the two chapters concentrates on particular aspects of the finance structure—for example, user fee collection techniques or the definition of federal and state responsibilities—rather than on comprehensive reform. However, decisions about changing any of these elements of the finance scheme in the future will be unavoidably linked, and proposals sometimes overlook these essential connections. Therefore, in comparing proposals, it will be

helpful to keep in mind a definition of a generic, comprehensive reform package. Such a package would have five components:

- *Defined goals:* The proposal should define what the finance scheme is intended to accomplish, with reference to overall transportation policy goals. Finance system goals should not only refer to revenue adequacy but also acknowledge that finance provisions influence transportation program outcomes, including operating efficiency and the quality of investment decision making.
- *Assignment of responsibilities* among the federal, state, and local government and the private sector: The appropriate assignment of responsibility will depend in large part on revenue sources, so if new revenue sources are contemplated, it will be necessary to think through the implications for spheres of responsibility. For example, to the extent that local and state governments have mechanisms to charge all users of roads within their jurisdictions rather than just residents, the need for involvement of higher levels of government is lessened. Changes in the control of revenue will translate into changes in control of spending and operating decisions.
- *User fee and pricing rules:* The proposal should identify sources of funds and, assuming user fees are employed, should specify how rates would be set. Today, federal and state elected officials directly decide the distribution of the burden of taxes and fees supporting transportation among categories of users (e.g., between light vehicles and large trucks) and the public. These decisions are influenced to an extent by transportation agencies' needs studies and cost allocation studies. In a finance scheme that relied heavily on revenue from tolls or mileage fees, success or failure would depend on the rules determining the levels of tolls and fees and the fee differentials corresponding to characteristics of users, traffic, and the facility. Revenue and demand management are not necessarily incompatible pricing objectives; however, both consequences of pricing decisions would have to be taken into account.
- *Rules on disposition of revenues* and on budget and project selection decision making: Today, as a consequence of the mechanisms of dedicated taxes and trust funds in federal and state transportation programs, transportation program spending is constrained by revenues during the intervals between legislative rate adjustments. Individual project selection is also influenced through the details of federal-aid program rules, such as matching share and project design requirements. A new finance scheme could involve different forms of connections between revenue and spending, or it could suppress any direct linkage. For example, if tolls or mileage charges become important sources of revenue, the revenue-raising potential of new road projects is likely to become a factor in project selection decisions, and components

of the transportation system that raise surplus revenue (e.g., the roads under control of a toll authority) may be able to claim priority in new spending plans. Also, new finance arrangements might alter the rationale or need for modal cross-subsidies.

- *A transition strategy:* Fundamental changes—for example, development of a new base revenue source or a substantial scaling back of the present federal role in finance—would have to be preceded by a coordinated program of research, planning, and communication among government officials and the public. The transition might involve large-scale trials and progress through a series of interim stages. A road map and schedule for the transition would be an essential part of a complete reform proposal (although the road map would be subject to revision throughout the process).

Given the complexity of the problem, it is not surprising that past proposals have not attempted to specify all these aspects of a finance scheme comprehensively. Nonetheless, as reforms are implemented over time, the inherent connections among the aspects will become evident. Therefore, it would be an error to plan at the outset to alter one aspect, for example, to replace the fuel tax with another form of user fee, while disregarding how the change might affect the other aspects of the finance system.

The review in this chapter covers two categories of proposals: first, substantial expansion of toll roads of the existing design; that is, limited-access roads whose users pay a fee, commonly upon exit and depending on the distance traveled and possibly on time of day; and second, direct metering of use of all roads within a geographic area [for example, by using Global Positioning System (GPS) technology], with charging based on distance traveled and possibly varying with the road, traffic conditions, or time of day. These proposals focus on developing new basic revenue sources and would require a period of years to implement (although toll road development is taking place today and may be stimulated by provisions of the 2005 legislation reauthorizing federal surface transportation aid programs). Chapter 6 describes proposed reforms that retain the basics of present arrangements, in particular, reliance on dedicated revenue from fuel taxes and other existing user fees. These concentrate on more effective use of existing instruments and could be implemented more quickly.

In its ultimate form, the road use metering concept would be a comprehensive approach to road pricing and finance reform. After a certain date, all vehicles would be required to have metering equipment, travel on all roads within the jurisdiction would be subject to charges, and the revenues would constitute the basic funding source for the transportation program. In contrast, toll road expansion proposals embody a more gradualist vision. The mileage of toll roads and tolled lanes would grow over time, both supplanting and supplementing traditional forms of funding and management. Eventually all the roads most suitable for

tolling with today's conventional technology (mainly urban arterial limited-access routes and major intercity expressways) would be tolled.

These three categories of reforms certainly are not mutually exclusive; rather, they could be complementary: reforms within the present system could be part of a phased transition strategy to a system that relied on tolls or mileage fees. (As an example, the Oregon road user fee proposal described below contains elements of all three categories.) General road use metering might emerge as a natural consequence of a program of expansion of conventional toll roads. The goal of examining the proposals is to assess the contribution that each of them might make to a finance scheme that promoted efficient operation and development of the transportation system.

TOLL ROADS AND TOLL LANES

It was noted in Chapter 2 that highway and bridge tolls account for 8 percent of U.S. highway user revenues (Table 2-2). This share has been nearly constant since the 1950s. Tolling of public roads has long faced opposition; the original federal-aid program for highways in 1916 banned tolling of roads receiving aid (P.L. 64-155, Section 1). Consideration was given to toll financing in the earliest stages of planning for the Interstate highway program, but a 1939 congressionally commissioned study concluded that most highways on a nationwide network would not generate sufficient revenue to be self-supporting, and later finance proposals all focused on the suite of fees and taxes in place today (Weingroff 1996). Except in some special cases, the federal-aid highway program does not allow states to collect tolls on Interstates or other roads built with federal assistance, although some preexisting toll roads were incorporated in the Interstate system and continue to collect tolls. In contrast with the United States, several countries, including Italy, Spain, Portugal, and France, have relied heavily on toll finance to develop their national expressway networks (Table 2-7).

Several recent developments have increased interest in (if not application of) toll finance. Information technology has greatly reduced the cost and inconvenience of toll collection. Today nearly every major toll facility provides for electronic toll collection. Communications devices in vehicles and at tollway entrances record the passage of a vehicle and charge the owner (for example, the E-ZPass system in place on most toll facilities in the northeastern United States). In addition, the search for additional revenue sources for transportation, especially in the states experiencing the highest rates of traffic growth, and hopes of attracting private investment in highways have stimulated attention.

The first subsection below surveys examples of proposals for expansion of the scope of tolling in the United States. In the second, the relation of tolling to private-sector participation in provision of roads is examined. The third describes

proposals and recent actions to change federal highway aid program rules to promote toll road development. The final subsection is a summary.

Proposals for Expanding Toll Roads

The four proposals described here are representative of efforts to work out a practical basis for increasing reliance on tolls in transportation finance on the basis of present tolling technology. The first, HOT (high-occupancy/toll) networks, is a conceptual proposal for a scheme that might allow relatively rapid development of a rational system of urban tolled lanes by starting with conversion of existing high-occupancy vehicle (HOV) lanes. The second, FAST (fast and sensible toll, or freeing alternatives for speedy transportation) lanes, is the original version of a proposal that was enacted in modified form on a trial basis in the 2005 federal surface transportation program reauthorization legislation. The underlying concept is similar to HOT networks, but the proposal is concerned with changes in federal law to give impetus to toll lane development rather than with laying out how the toll system should develop. Both proposals call for toll lanes rather than toll roads because offering motorists a choice between tolled and free lanes is viewed as a way to mitigate public objections to placing a toll on previously free facilities. The third proposal described is for development of toll lanes restricted to use by large trucks. The final proposal (a measure adopted by the state of Texas) is a plan to restructure state transportation programs to allow tolls to take on a greater role in funding.

HOT Networks

The HOT networks concept, proposed in a 2003 study of the Reason Public Policy Institute, is an example of an incremental approach to expanded use of tolls for finance and facilities management (Poole and Orski 2003). The authors call for development of networks of HOT lanes on limited-access expressways in congested urban areas. The lanes would be open toll-free to multioccupant vehicles (as are today's HOV lanes) and to single-occupant vehicles paying a toll. Toll collection would be electronic, and the fare would be varied according to actual traffic conditions to maintain freely flowing traffic at all times. The lanes also would be open to express buses to provide low-cost, high-speed public transit. Development of the system would start with existing infrastructure by converting existing HOV lanes to HOT lanes, and additional mileage of lanes and interchanges would be added to create a rational network in each metropolitan area.

The proposal incorporates features aimed at broadening public acceptance. HOT lanes would be marketed as a premium, congestion-free service option, with drivers offered the choice of congestion-free toll lanes alongside more crowded free lanes, and the system would improve transit as well as private auto mobility.

To illustrate the proposal, the authors present maps, cost estimates, and revenue estimates for HOT networks in eight highly congested U.S. metropolitan areas. The networks range from 240 to 1,000 lane miles each and total 4,400 miles in the eight cities (Washington, D.C.; Miami; Atlanta; Dallas; Houston; Seattle; San Francisco; and Los Angeles). The estimated construction cost is $44 billion (not including the cost of constructing the HOV lanes already in place). Toll revenues are estimated to be $2.9 billion per year and to be sufficient to cover two-thirds of the debt service on the construction cost, with average peak-period tolls around $0.26 per mile. The authors propose that the federal government take the lead in implementing the plan by offering aid within the structures of the existing federal highway and transit programs.

FAST Lanes

FAST lanes was a legislative proposal, originally put forth in 2003, to lift the prohibition in federal law on collection of tolls on federal-aid highways for new lanes, lanes on new highways, or existing HOV lanes that are converted to toll lanes, provided that the highway has a free lane parallel to the toll lane. A version of the proposal, entitled the Express Lanes Demonstration Program, was enacted as a trial in the 2005 federal surface transportation program reauthorization legislation [Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Section 1604]. The secretary of transportation is authorized to permit 15 projects with the following features:

- A state or a state-authorized public or private entity may impose tolls on an existing HOV lane or a newly constructed lane on any road, including Interstate highways. Capital expenditures for the project will be eligible federal-aid expenditures.
- The purpose of the tolls must be to manage congestion, reduce emissions, or finance the lane addition. The state must set performance goals for the project and monitor and report performance.
- Revenues are to be used first to pay for debt service (presumably on debt incurred to construct the facility), for a "reasonable return on investment of any private financing," and for operation and maintenance of the facility. Any surplus is to be used for any federal-aid highway or transit project.
- Former HOV lanes converted to toll lanes must have variable pricing by time of day or by level of congestion. Newly added lanes may use variable pricing but are not required do so.
- Toll collection must be automated, and the U.S. Department of Transportation is to set standards to ensure interoperability of tolling equipment.

Another section of the same legislation (SAFETEA-LU, Section 1121) authorizes conversion of HOV lanes on federal-aid roads to HOT lanes. Design and operating requirements are similar to those of the Express Lanes Demonstration Program listed above, but there is no restriction on the number of projects. How the two provisions of the act will work together has not yet been established.

An analysis of the potential extent and feasibility of FAST lanes projects (Poole 2003) considered a scenario in which states decided to add two FAST lanes to all Interstate highway segments classified as severely congested by the Federal Highway Administration (with volume–capacity ratio over 0.95 in the peak direction during the peak hour). There are 3,600 miles of such routes, nearly all in urban areas. Estimated construction costs were $57 billion to $84 billion, and toll revenues were estimated to be sufficient to cover between 33 and 57 percent of these costs. It was noted that FAST lanes on high-volume expressways in smaller urban and rural areas might be better able to pay for themselves because construction costs would be much lower than in the largest urban areas, although such projects would yield lower travel benefits.

The inability of HOT network or FAST lane projects in major urban areas to pay for themselves would not be surprising and would not necessarily imply that such projects were economically unjustified. The lanes would all be competing with untolled and hence underpriced capacity, including the adjacent free lanes that are part of the design of these projects as well as alternate routes over the urban network. Also, it is likely that highway agencies would choose not to build some of the capacity expansions that are included in the estimates of cost and revenue described above because their construction and operating costs would be too high in comparison with toll revenue and benefits. Eliminating the least attractive projects would boost the ratio of revenue to costs.

Features of the FAST and HOT lane concepts that are aimed at increasing public acceptance—the adjacent free lanes and the guarantee of free-flowing traffic at all times in the premium lanes—compromise their effectiveness and financial viability. One study illustrating this difficulty used a travel demand model to compare the performance of a hypothetical expressway with congestion tolls on both lanes in one direction with performance with only one lane tolled (Parry 2002). The study estimated that the economic benefit from providing both a tolled and a free lane would be no more than a third of the benefit of tolling both lanes. (The benefit is the value of travel time savings and of new trips resulting from the increase in speed in the tolled lane, net of the loss to travelers who are displaced by imposition of the toll.) The optimum toll on a single tolled lane would be only a fraction of the optimum toll if both lanes paid. If the single-lane toll were increased above its optimum level, the cost of added congestion caused by diverted traffic in the free lane would exceed the added benefit of reduced congestion in the tolled lane. Also, providing separate tolled and free lanes may add to the construction

cost of the facility by complicating interchange design. Similarly, guaranteeing free flow in the tolled lane can reduce the public benefit compared with allowing some degree of congestion there, if diverted traffic increases delay in the free lanes enough to offset the benefits to users of the tolled lane. In one simulation study (Small and Yan 2001, 321), guaranteeing free traffic flow in the tolled lane harms overall public welfare under nearly all assumptions.

Imposing a toll on a single lane will not necessarily harm users of the free lanes. If the tolled lane had been congested to the point of stop-and-go traffic flow conditions before tolling, then imposing a toll will increase throughput on the tolled lane and may decrease congestion in the free lane. Also, if the tolled lane was previously an HOV lane, it may have been so lightly utilized that opening it to toll-paying vehicles will decrease congestion in the free lanes. Regardless of prior conditions, however, the optimum toll generally will still be lower than if all lanes were tolled.

Truck-Only Toll Lanes

Another possible near-term application of specialized toll lanes is new lanes for trucks only on Interstate routes with heavy truck traffic. A 2002 analysis of such facilities estimated the potential productivity gains of truck-only toll lanes on long-distance Interstate routes and concluded that in many cases truckers would willingly pay tolls in the range of 40 to 80 cents per mile to obtain the increased payload benefits (Samuel et al. 2002). That study proposed that longer combination vehicles (for example, a tractor pulling two full-sized semitrailers) be required to use the truckways but that conventional heavy trucks, which are legal on all Interstates, have the option of using either the truckway or the regular lanes.

The rationale for such facilities is partly fiscal and partly operational. On the fiscal side, states see toll financing as a means to finance widening of heavily traveled Interstate highways over the next 20 years. The operational rationale is a combination of safety and productivity. Separation of cars from heavy trucks is expected to produce significant safety gains. Also, if heavy trucks operate in barrier-separated lanes, there should be fewer safety objections to longer and heavier combination vehicles, which can significantly increase the productivity of trucking by permitting a single rig and driver to haul more payload. In urban areas, relief from freeway congestion should further enhance productivity gains to truckers. The voluntary approach, with free lanes and toll lanes accessible to conventional trucks, might have more success in gaining trucking industry support than mandatory tolls, which the industry has opposed (McNally 2005).

Truck-only toll lanes feature in the plans of several public agencies. In 2005 the Virginia Department of Transportation was considering proposals of a private-sector bidder for an $11 billion project to add two truck-only toll lanes in each direction to all 325 miles of I-81 in Virginia. The possible tolling of all lanes on

I-81 is under consideration as part of this project (Bowman 2004; VDOT 2005). In Texas, the first of a number of long-distance trans-Texas corridors has entered the negotiation stage with the Texas Department of Transportation's selection of a winning bidder for the first major segment of the corridor that will parallel I-35. This $6 billion project will initially build a four-lane divided toll highway open to all traffic. When it is subsequently expanded to as many as 10 lanes, the original four lanes will become truck-only lanes (Powers 2004). In California, the 2030 long-range transportation plan adopted in 2004 by the Southern California Association of Governments includes a $16.5 billion system of toll truckways, in part to serve the ports of Los Angeles and Long Beach (Southern California Association of Governments 2004).

Texas Toll Road Authorizing Legislation

Programs created by a referendum passed in 2001 and subsequent legislation seek to integrate use of toll roads and debt finance as components of the Texas state transportation program. This ambitious reform package is too new to allow an assessment of its impact, but it is being cited as a model for other states. The new law authorized creation of county-level or multicounty toll road authorities, called regional mobility authorities (RMAs). RMAs must work with the existing metropolitan planning organizations, which retain authority over planning transportation development in their local areas. The goal of the RMAs is to give metropolitan areas greater control over development of their highway systems and to accelerate projects that would not receive high priority in the statewide program (TxDOT 2004; Orski 2004; *Urban Transportation Monitor* 2004).

RMAs can issue bonds backed by toll revenues, develop projects, operate toll roads, and contract with private-sector firms to build and operate toll roads. They also have access to regular state highway funds and federal aid to the extent allowed under federal program rules.

The law provides for payments of per-vehicle fees, called shadow tolls or pass-through tolls, to RMAs by the state to compensate the RMAs for the costs of roads they provide to the state as part of the state highway system. The provision's purpose apparently is to allow the state to subsidize low-revenue toll projects with general state highway user fee revenue or to associate a revenue stream with untolled RMA projects for financing purposes.

At the state level, the new laws created the Texas Mobility Fund and authorized the state to sell bonds to finance new road construction. The commission has required the state department of transportation to evaluate all new state construction for feasibility of tolling.

Three RMAs have been formed, and two more are being organized. RMA projects involving more than 100 miles of road construction costing several billion dollars are in early stages of development. The Texas program is noteworthy as an

effort to mainstream tolls as an element of state transportation finance. It focuses on metropolitan areas and gives metropolitan areas lead responsibilities since these areas are where most of the promising toll projects will be located.

Programs similar to the Texas RMAs exist in other states. In Colorado, the 1987 Public Highway Authority Law allows cities and counties to create special authorities with the necessary powers to construct and operate toll roads. Two authorities operate toll roads in the Denver area under the law's provisions, one funded entirely by toll revenue and the other by a combination of toll revenue and a special local vehicle registration fee (E-470 Public Highway Authority 2005; Northwest Parkway Public Highway Authority 2004). The state also has created the Colorado Tolling Enterprise, which is authorized by the legislature to issue bonds and construct and operate toll roads at any location in the state, consistent with the state and regional transportation plans (Colorado Tolling Enterprise Board 2005). In Florida, independent regional expressway authorities in Miami, Orlando, Kissimmee, and Tampa operate networks of toll roads.

Private-Sector Participation and Toll Finance

The possibility of increasing the resources available for expanding capacity by eliciting private-sector participation has begun to receive serious attention. Most such projects and proposals have been for toll roads constructed entirely or partially with private-sector capital and operated by a private entity.[1] Nearly all U.S. toll roads today are operated by publicly controlled special-purpose authorities. Tolls are the obvious choice for funding privately operated roads because an identifiable revenue stream is necessary for attracting private capital and because one of the hoped-for benefits of such projects is an improvement in efficiency through operating the road on business principles, including charging for use. Thus measures to promote toll finance of U.S. roads may also increase the opportunity for private-sector participation.

The number of such projects carried out in modern times in the United States is small thus far; a 2004 General Accounting Office (GAO) report identified five private toll roads (GAO 2004). Two of the most prominent projects are located in Southern California. The State Route (SR) 91 Express Lanes project, 10 miles of tolled express lanes with variable time-of-day pricing, constructed in the median of an existing freeway, opened in 1995 as a privately operated road. The facility was later purchased by a public authority because the government wished to construct parallel capacity in violation of its noncompete clause with the franchisee.

[1] The most common form of public–private partnership, as the term is used conventionally in U.S. transportation, is a contract in which a private firm takes responsibility for design, construction, and often operation and maintenance of a road and bears part of the risk of cost or schedule overruns or performance failures (USDOT 2004). These arrangements and other management controls to make available resources go further are described in Chapter 6.

The second California project is a new 10-mile expressway, a section of SR 125, scheduled to open as a privately operated toll road in 2006. In 2005, in the first privatization of a public toll road in the United States, the city of Chicago turned over operation of the Chicago Skyway, an 8-mile expressway constructed in 1958, to a private firm under a 99-year lease. The operator will receive all toll revenue (which amounted to $43 million in 2002) in return for a $1.8 billion payment to the city. The operator has instituted time-of-day pricing for trucks.

The California private toll road projects were developed through the program created by Assembly Bill 680, 1989 California legislation that authorized the state transportation department to enter into agreements with private entities for construction and operation of four toll road projects, as demonstrations, to be carried out without state funds. The statement of findings introducing the law indicates that the program is to develop alternative funding sources "to augment or supplement available public sources of revenue," to "take advantage of private-sector efficiencies in designing and building transportation projects," and to "allow for the rapid formation of capital necessary for funding transportation projects" (Caltrans n.d.).

In a presentation to the committee, a California official emphasized that the state saw the AB 680 projects primarily as a way of supplementing funding. The law was enacted at a time of exceptional constraint in the state transportation budget. During the 1990s, growth in state revenues and federal grants diminished interest in recruiting private capital for road development. However, interest has been renewed now that transportation budgets are tightening again. Similarly, the SR 125 franchisee described the project's funding arrangement to the committee as a means of allowing construction of a road for which funding would otherwise not have been available.

Enabling Legislation

Provisions in state law that set ground rules for participation in road development are seen as critical to the prospects for these kinds of projects. For example, AB 680, the legislation governing the California projects, authorized up to four projects subject to the following provisions:

- Projects are to be constructed entirely at private-sector expense.
- Roads are to be leased by the state to the private operator for 35 years and then revert to state operation.
- The state transportation department "may exercise any power possessed by it" (presumably a reference to eminent domain) to facilitate projects.
- The state can provide planning and environmental certification services, with costs to be reimbursed by the operator.

- The state will provide maintenance and traffic law enforcement, with reimbursement.
- All design and environmental standards applicable to conventional state projects apply.
- The private party's return is capped at "a reasonable return on investment."

As the owner of the roads, the state retains liability for their operation. The state also provides access to certain financing sources, for example, federal credit assistance. In the SR 91 project arrangement, the state agreed not to construct competing facilities.

The GAO assessment of private-sector participation in road and transit projects found that legal authority exists in 20 states for private-sector participation in highway projects (GAO 2004, 5). The Texas toll road legislation described in the preceding section is an example of a recent legislative charter.

Prospects for Private Participation

GAO's assessment concluded: "While legislative proposals [during the congressional debate over reauthorization of the federal surface transportation program] could encourage greater private participation, private sponsorship seem[s] best able to advance a small number of projects—but seems unlikely to stimulate significant increases in funding for highways and transit" (GAO 2004). GAO cites as obstacles the absence of authorizing legislation in most states, as well as "significant political and cultural resistance to toll roads—the most common way that the private sector generates revenues" (GAO 2004, 5). However, it emphasizes the impact on toll revenue from competition between free roads and toll roads as the primary obstacle and observes that "absent fundamental changes to current federal transportation programs, states are likely to continue to devote significant funding including federal funds to building untolled roads."

The perspective of GAO's assessment, that private participation should be judged in terms of its ability to increase total funding for transportation, seems to parallel the perspective of the states (for example, in California's AB 680 program described above). However, it is not evident that the choice between private and public ownership and operation of toll roads should be viewed primarily as a funding issue. Increasing private-sector participation will not necessarily increase the total funds available for roads or allow accelerated road investment if the toll revenues that would attract private-sector partners and backers are available to the government acting alone. Instead, the choice to involve the private sector should be viewed as similar to other privatization decisions that governments have faced in regard to a variety of services and administrative functions with similar potential benefits and drawbacks. For example, the private sector may have costs differ-

ent from those of the government, and political pressures and public expectations may affect the relative flexibility of public and private toll road operators to set prices for road use.[2]

Pricing policy is key to gaining the potential efficiency benefits of toll roads. It has even been argued that privatization will be essential for effective application of pricing and effective use of the information that pricing would provide to guide highway management (Winston 1999). The record on the ability of public and private operators to price flexibly is mixed. Traditional public toll road authorities have hesitated to introduce variable pricing, but some are now doing so. One important highway congestion pricing experiment in the United States, the California SR 91 Express Lanes, is now operated by a public authority but was originally developed and operated by a private-sector firm. A local government operating toll roads might be tempted to use its power over tolls to "export" traffic to neighboring communities (De Borger et al. 2005) or, alternatively, might feel obliged to compete with its neighbors for commercial activity by reducing tolls below costs.

As the cost estimates described above for the HOT network and FAST lane proposals suggest, it will not be possible to have extensive self-supporting toll roads and optimal traffic patterns if travelers are always offered untolled or subsidized alternatives. One response to the problem of competition from untolled roads would be to subsidize toll roads (as the Texas toll road legislation described above apparently would allow). If tolling parallel routes is not practical, a toll road's failure to generate revenue sufficient to cover its cost is not proof that the benefits of the road are less than its costs. In this case, a subsidy to the toll road, to reduce the distortion of travelers' route decisions, might be economically justified. Such subsidies, paid from traditional road user fee revenues, could serve as a transitional step toward more widespread dependence on toll revenue.

The California SR 91 and SR 125 toll projects were developed under highly favorable circumstances for a private road: high congestion and rapid growth ensured high demand and revenue potential; the state had already completed environmental reviews on SR 91, which greatly reduced the risk that the project would be stopped; and right-of-way already existed for the SR 91 Express Lanes. There may be few projects with similar circumstances in the future, in California or elsewhere. In general, where demand and revenue potential are high, environmental and right-of-way obstacles will also be high (Boarnet et al. 2002). Expanding the pool of attractive potential private road projects may therefore require granting more concessions to the franchisee than California's AB 680 allowed. More recent laws in other states (for example, the Texas legislation described above) may prove

[2] For thorough examinations of the potential benefits and limitations of privatization and of the circumstances in which it is likely (and unlikely) to be beneficial, with examples from transportation, the reader is referred to Gómez-Ibáñez and Meyer 1992 and Donahue 1989.

more conducive to tolling and public–private partnerships than the California AB 680 pilot program.

Federal Policy Changes Favorable to Toll Road Development

In general, toll advocates have sought changes in law to remove restrictions on institution of tolls on federal-aid highways, to give toll roads and roads developed with private participation the same access to federal aid and tax-favored financing as conventionally developed roads, and to have government retain some of the risk of project delays related to regulatory requirements. The 2005 federal surface transportation aid reauthorization legislation (SAFETEA-LU) contained provisions to

- Classify federal-aid highway projects as eligible for tax-exempt private-activity bond finance, with a $15 billion nationwide cap on such bonds over the life of the bill (Section 1143). (This provision appears to apply mainly to financing projects with mixed public–private funding. Government-owned airports, docks, and wharves were already eligible for tax-exempt financing, but highways had been excluded.)
- Allow tolls on newly constructed express lanes or former HOV lanes on federal-aid highways through the Express Lanes Demonstration Program and HOT lanes provisions described above (Sections 1604 and 1121).
- Authorize an Interstate System Construction Toll Pilot Program (Section 1604) limited to three projects nationwide. The program would allow tolls on Interstate highways, bridges, or tunnels for the purpose of financing construction of the facility. This provision apparently is in addition to a previously authorized pilot program that allows up to three projects in which a state collects tolls on an Interstate to finance reconstruction of the highway.
- Expand the Transportation Infrastructure Finance and Innovation Act credit assistance program that was the source of part of the funding for the California SR 125 private toll road.

The restriction of tolling to limited numbers of projects in pilot programs is a compromise. The states had advocated elimination of federal restrictions on tolls, while the trucking industry had led opposition to lifting restrictions (Fischer 2004, 31–33; McNally 2005; *AASHTO Journal* 2004). The states have made little use of previous federal tolling pilot programs.

A private-sector view on policy changes needed to promote toll finance is indicated in a proposal from a firm active in toll road projects internationally (and the parent of the SR 125 franchisee). The proposal (James 2003) calls for the following changes in federal law:

- Make development phase activities (planning, environmental review, permitting, and preliminary design) for privately owned or operated projects

eligible for federal funding. The object apparently is to impose on the state a major share of the risk that projects will fail to pass environmental and other permitting reviews.

- Expand federal highway and transit grant programs to allow federal funding of projects that are privately constructed, owned, and operated, with grant funds passing through the states. Presumably the concept is that if the state were planning to construct a facility that was not expected to be self-supporting through user fees, it could solicit proposals for private participation and select the proposal that produced the project at lowest cost to the state.
- Mandate consideration of private financing for highway and transit projects. Such a mandate is seen as necessary to change conventional attitudes of government planners toward private participation. This requirement exists in the United Kingdom.
- Allow tolling on Interstates.
- Facilitate private-investor access to tax-exempt financing, in part by expanding the definition of "exempt facilities" eligible for funding with tax-exempt private activity bonds to include highways.
- Facilitate state sale or lease of facilities to private investors by clarifying that such transactions involving facilities built with federal aid are permissible.

As described, the 2005 surface transportation legislation contained measures in the direction of some of these proposals.

Summary

With the toll collection technology in use now in the United States, the two main technical limits on the potential of tolls in highway finance are that tolls can be applied on only a fraction of the road system and that toll roads always directly compete with untolled roads.

State and local governments spend roughly $22 billion annually, about one-sixth of all highway spending, on construction, reconstruction, maintenance, and operation of urban and rural limited-access freeways (that is, the roads whose design is suitable for tolling with conventional technology and that are not now tolled). Revenue from existing toll roads and bridges was $7.7 billion in 2003 (FHWA 2004, Table SDF; FHWA 2005, Table LDF). The estimates summarized above indicate that tolls imposed on urban HOT network or FAST lanes might typically be expected to generate revenue sufficient to cover half the capital cost of the lanes. On this basis, an ambitious program of toll conversion and new toll road development in the United States today, following the HOT network or FAST lanes models, might at most double annual highway toll

revenue. Although electronic toll collection has greatly reduced the physical infrastructure required for tolling, retrofitting some existing urban expressways for tolls might prove impractical because of physical constraints or high initial costs. Imposing tolls on all lanes of selected heavily traveled intercity routes, on the model of the existing turnpikes, might generate substantial additional revenue, but this measure has received consideration only in a few locations. The added revenue from tolls probably would reduce legislatures' willingness to raise fuel tax and registration fee rates, so the net increase in highway budgets would be less than the added toll revenues.

A toll program on this scale could have significant benefits even though toll revenues would remain a small fraction of total highway spending. It would improve traffic flow on the tolled facilities (provided congestion pricing was employed) and speed construction of needed projects. If states evaluated all proposed major capacity expansions for their potential for toll finance (a practice now in force in Texas and recommended for Oregon in that state's Road User Fee Task Force proposal), project selection would be improved because projects with the least direct benefit and therefore the least potential for toll revenue would tend to be deferred. Perhaps most important, an expanded toll program would allow officials and the public to gain experience with road pricing and consider whether more extensive application would be desirable.

As the GAO review of U.S. private road projects (GAO 2004) observed, competition with untolled roads will restrict the revenue toll roads can generate. Except in some settings where before tolling the road regularly experienced stop-and-go traffic conditions, imposing tolls will divert traffic to parallel lanes and roads and increase delay and accident costs on these roads. The responsible government authority must take care that tolls are not set so high that the net effect for all travelers is negative.

The following measures probably are prerequisites for substantial expansion of tolling and recruitment of private-sector participation in toll road development: access to federal aid for toll roads and to tax-favored financing for privately developed roads, mechanisms for funding toll facilities that are not expected to have toll revenue sufficient to break even (e.g., the pass-through toll mechanism in the Texas toll road program), and continued advances in improving the convenience and reducing the cost of electronic toll collection devices. Also, governments will need to give consideration to the appropriate public and private shares of risk from regulatory delays in projects.

The unpopularity of toll roads and public skepticism toward the concept of road pricing are recognized as fundamental obstacles (Stough et al. 2004, 17–19; McNally 2005). The following are among the objections commonly expressed: paying tolls is inconvenient and slows travel; when a toll is placed on an existing road the users are being forced to pay for the road twice; congestion tolling rewards highway agency inefficiency, since the worse the congestion the greater the rev-

enues; tolls inequitably burden the poor; congestion pricing in effect reserves road use for the wealthy; road use metering technology constitutes an invasion of privacy. However, the evidence on public acceptance is mixed. For example, a recent metropolitan Washington, D.C., opinion survey found a marked public preference for tolls over tax increases for funding new roads (Ginsberg 2005), and some new toll projects have gained public acceptance (FHWA 2003, 30).

The proposals described above contain features intended to help gain public acceptance—in particular, offering users a choice of toll lanes, free lanes, and transit, rather than forcing all travel onto the toll facility. However, these provisions reduce the public economic benefits that can be gained through pricing. The opportunity to accustom a larger share of the public to the idea of road pricing gradually sometimes is cited as one important benefit of incremental expansions of tolling and demonstrations of new kinds of toll roads (Parker 2004). The problem of public acceptance is examined further in the next section.

ROAD USE METERING AND MILEAGE CHARGING

This section describes proposals and projects involving direct metering of use of an extensive network of roads for the purpose of imposing charges on each road user that depend on miles traveled. Charges also could vary with other factors related to the cost of the user's trip, such as the specific road used, traffic conditions, and time of day.

This method of charging for road use would have several advantages. If mileage fees largely replaced fuel taxes, user fee payments would no longer depend arbitrarily on vehicle fuel efficiency or the type of fuel consumed, and revenues would not be vulnerable to shifts in vehicle technology. In addition, if all use of all roads were monitored and charged for, local governments could readily fund their streets and roads with revenue from user fees, as the states do now, rather than relying on general or general sales taxes. Most important, the benefits of the transportation system to travelers and the public could be substantially increased, because travelers would have incentives to use roads efficiently and road authorities would have better information to guide investment decisions.

Trucks have paid mileage fees in several U.S. states for many years. The weight–distance tax in Oregon produces the most revenue, $178 million in 2003 (FHWA 2004, Table MV-2). Oregon rates are from $0.04 to $0.185 per mile depending on the truck's registered weight and number of axles (ODOT 2004). Fuel consumed by trucks paying the weight–distance tax is exempt from the state fuel tax. Truck operators must periodically report their trucks' in-state and out-of-state mileage and submit payments (Rufolo et al. 2000).

Applying a fee-charging system similar to the Oregon truck weight–distance tax to cars and small trucks would impose impractical requirements on all vehicle

operators to record and report their mileage. Mileage charging even for large trucks has not gained wide acceptance, in part because of the burden of manual recording and reporting. Therefore, all recent proposals for charging mileage-based fees have involved automated data collection. Technology is available that could accurately and reliably measure each vehicle's travel and assess charges at reasonable overhead cost and without great inconvenience for vehicle owners.

Proposals for road use metering and mileage-charging systems must address not only technical plans but also administrative and political problems more challenging than the engineering aspects. Among these problems are the following:

- Gaining public acceptance of a system that may force some road users to pay more or travel less and that employs technology sometimes regarded as a privacy threat,
- Managing the transition from the present transportation funding scheme to a new one, and
- Learning how to set fees properly so that the potential economic benefits of the new charging scheme are realized.

The first subsection below is a summary of proposals and projects for mileage charging and other forms of road pricing. The next two subsections present examples of proposals for road use metering and charging systems in the United States and experience with such systems applied to trucks in Europe. The final subsection discusses implementation issues.

Survey of Proposals and Projects

The committee commissioned a review of projects and planning studies involving road use metering and mileage charging and related road pricing schemes in the United States and other countries (Sorensen and Taylor 2005). The review covered proposals for measuring or observing road use within a geographic area or on an extensive network of roads and for imposing charges that depend directly on miles driven, the specific roads used, time of day, or traffic conditions. Cordon tolls (i.e., schemes in which vehicles are charged for entering or traveling within an area) and toll roads with variable rates were included, but traditional turnpikes charging flat rates were not covered in the survey. Projects were included that have purposes other than assessing road use fees but that demonstrate techniques that could be applied for that purpose, for example, systems to monitor commercial vehicles for regulatory enforcement. For each project or proposal, the review examined

- The objectives and history of the system,
- Techniques of metering road use and collecting fees,

- Pricing policy,
- Governance (that is, control of policies and revenue),
- Experience with public acceptance, and
- Uses of revenues and sources of funds for constructing and operating the system.

The review disclosed a high level of interest in road pricing and road use metering among road authorities worldwide, although implementation is in only the earliest stages. Eighty-eight relevant projects were identified. Most are still in the proposal stage, and the systems in operation are nearly all cordon tolls or variable tolls on expressway segments. Table 5-1 shows the kinds of projects reviewed. Appendix C is a summary of the review.

A recent proposal in the United Kingdom, which was not covered in the commissioned review, is worth mentioning because of its breadth. The government has committed itself to a policy of developing a nationwide road pricing scheme within the next 10 to 15 years that would impose charges on all road travel according to distance traveled and congestion conditions. A conceptual plan has been developed for a system using satellite positioning technology and metering devices in vehicles. The concept is thus similar to the U.S. proposals and the existing German truck tolling system described below. Regional or local pilot implementations are envisioned as a stage in development of the system. In the government's policy, revenue from mileage charges would be offset by reductions in the motor vehicle fuel tax (European Commission 2005; Darling 2005; Department for Transport 2004, Chapter 3).

The remainder of this section concentrates on proposals for road use metering and mileage charging. These schemes appear to be the most promising alternatives to the gasoline tax as a primary revenue source and as a means of assessing user fees applicable to all vehicles and roads. In contrast, cordon tolling usually is seen primarily as a traffic management measure applicable in a restricted area. The review found no proposals for application of a zone charging scheme over an extensive area.

U.S. Proposals for Road Use Metering and Mileage Charging

The Oregon Road User Fee Task Force proposal and the *New Approach to Road User Charges* study, which were cited in Chapter 1, are the most prominent U.S. proposals for road use metering and charging schemes intended to replace or substantially supplement fuel taxes as a basic revenue source for transportation programs. The two proposals are similar in conception but differ in some significant design details. Together they suggest the range of design issues that will require evaluation.

TABLE 5-1 Road Pricing, Road Use Metering, and Mileage-Charging Projects and Proposals

	Number of Projects in Operation		Number of Projects Planned or Proposed	
Type of Application	**U.S.**	**Other Countries**	**U.S.**	**Other Countries**
Facility congestion tolls: Toll on a highway segment, bridge, or tunnel that varies with traffic conditions or time of day.	7	4	28	6
Cordon congestion tolls: Road users pay a fee to enter or travel within a geographic zone (e.g., a city center) during certain hours.	2	6	1	9
Road use metering and mileage charging: Miles driven by all vehicles on a road system are monitored and operators charged a fee depending on mileage.			6	7
Weight–distance truck fees: Mileage of freight-carrying trucks is monitored and operators pay fees depending on mileage and weight (count includes only projects involving automated travel monitoring).		2		5
Distance-based price variabilization: Measures to convert fixed vehicle fees (e.g., registration and insurance) to fees depending directly on miles driven.			5	

NOTE: The counts include projects and substantial proposals that were identified through a literature review and for which sufficient documentation was available. They are not exhaustive but indicate the extent of interest in the various types of application.

SOURCE: Sorensen and Taylor 2005, Appendices B–F.

In addition to these two proposals, a plan for a test of a road use metering and mileage-charging system involving 500 vehicles in Seattle, Washington, was announced in 2005 by the Puget Sound Regional Council. The test is receiving funding from the federal Value Pricing Pilot Program. The technology is related to that of the German Toll Collect truck-charging system (described below) and is supplied by the firm that developed the German application (*Inside ITS* 2005).

Oregon Road User Fee Task Force Proposal

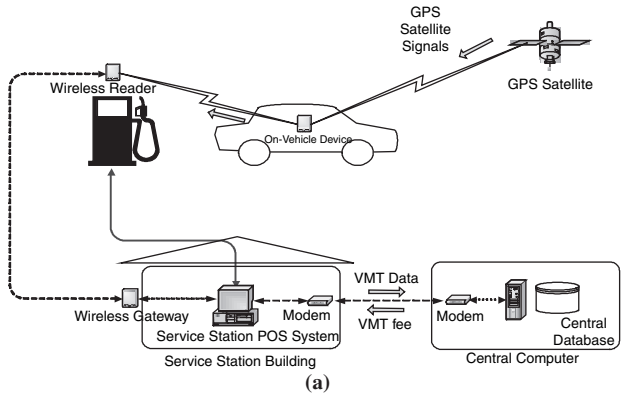
The Oregon Road User Fee Task Force was charged by the legislature with designing a method of charging users of the state's roads to replace the current system. The task force's proposal has three main provisions (Road User Fee Task Force 2003):

1. Eventual imposition of new charges in place of existing ones:
   – A mileage fee, that is, charging a fee per mile driven on the state's roads.
   – Congestion pricing, that is, charging a fee for use of certain roadways during periods of congestion.
   – New facility tolling: collecting tolls on all newly constructed roads, bridges, or lanes, to the extent practicable, to cover the costs of construction, maintenance, and operation.

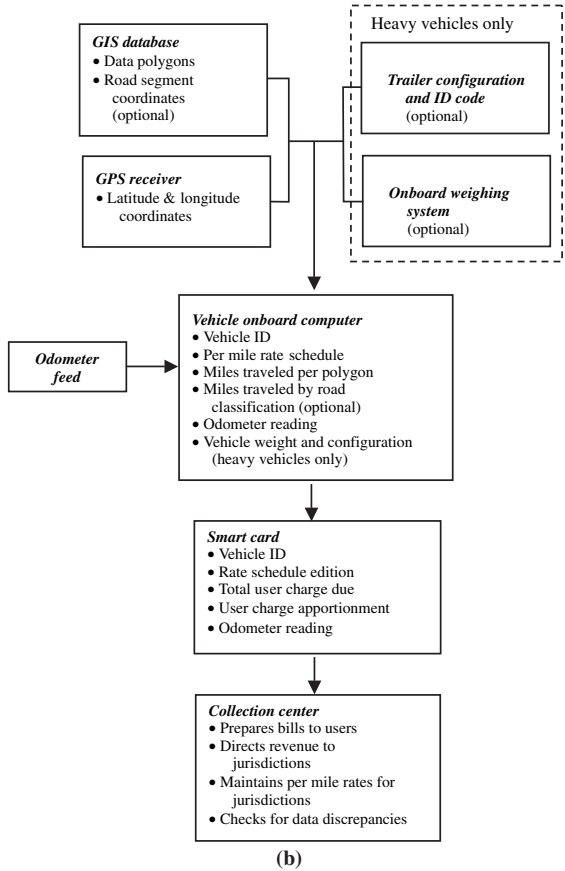
   The report explains that "the only broad revenue source that the task force believes could ultimately replace the fuel tax is a mileage fee. The other . . . revenue sources would address specific problems related to road revenue and are designed for certain geographical areas, certain road projects, or certain road users" (p. 2).
2. A 20-year phase-in period during which the state would operate both the mileage fee and the fuel tax. All new vehicles would be equipped with the meters necessary to collect the mileage fee, and their owners would receive credits or refunds of their fuel tax payments.
3. Pilot testing of alternative hardware and administrative arrangements for the mileage fee as the first step toward implementation.

The task force recommended pilot testing of metering and charging technology with the following features (Figure 5-1):

- Mileage would be recorded on board the vehicle either with a system using a GPS receiver to determine distance and location of travel or with a device for recording miles driven from the vehicle's odometer. Both options would be evaluated in the pilot test. The GPS option would allow imposition of congestion charging or charges that depended on the physical characteristics or ownership of the road.
- Only the minimum summary data required to compute the charge would be transmitted outside the vehicle; this information would be insufficient to allow reconstruction of the routes and times of travel of the vehicle.
- Fees would be collected by one of two alternative methods. In the first, at each refueling a device on the fuel pump would receive a transmission from the vehicle's mileage recorder, add the mileage charges accumulated since the



(a)



(b)

FIGURE 5-1 Examples of design proposals for road use metering and mileage charging: (*a*) Oregon Road User Fee Task Force proposal, GPS option (source: Whitty and Imholt 2005); (*b*) *New Approach to Assessing Road User Charges* proposal (source: Forkenbrock 2004).

previous refueling to the price of the fuel purchase, and subtract the state's fuel excise tax from the purchase price. In the second option, the vehicle's mileage meter would be read at service stations or other data collection centers, and the state would periodically send the vehicle owner a bill for mileage charges less fuel excise tax paid.

The task force estimated that the largest capital cost associated with road use metering would be the cost of in-vehicle equipment, on the order of $250 per vehicle for prototypes. However, it noted that the main component, the GPS navigation system, probably will become standard equipment on automobiles soon, so much of this cost will not be attributable to the charging scheme. Total initial capital expenses for setting up central facilities and installing devices at gas stations are estimated at $33 million (Whitty and Imholt 2005, 41–42). Estimated annual operating costs for a central data collection and billing center are $50 million, but state administrative costs for the decentralized fee-collection option (with the entire mileage fee transaction handled at the gas pump and no central data collection) were estimated to be much less (Road User Fee Task Force 2003, 31). For comparison, Oregon had 3.1 million registered vehicles and collected $640 million in state highway user fees in 2003 (FHWA 2004, Tables MV-1, SF-1). For the United States as a whole, collection expenses for present state highway user fees are 5 percent of revenue collected (FHWA 2004, Table HF-10). The state planned to conduct a 1-year pilot test of the technology involving several hundred vehicles in Portland, Oregon, beginning in 2006. The operators will pay mileage charges and have fuel taxes deducted at the gas pump (Whitty and Imholt 2005).

New Approach to Road User Charges *Proposal*

A proposal developed with the support of 15 state departments of transportation calls for a road use metering system that could be implemented nationwide but that would provide flexibility so that each state or substate jurisdiction could decide independently whether to charge mileage fees and establish its own rate structure (Forkenbrock and Kuhl 2002; Forkenbrock 2004). The 2005 federal surface transportation aid reauthorization legislation (SAFETEA-LU, Sections 1919 and 1934) authorized a 3-year, large-scale field test of the technical approach of the *New Approach to Road User Charges* proposal funded at $16.5 million. The main elements are as follows (Figure 5-1):

- Each vehicle would be equipped with an onboard computer. The computer would receive inputs from a GPS receiver and the vehicle odometer and would contain a data file defining the boundaries of taxing jurisdictions and tax rates.

- In the simplest implementation, the fee schedule would be a flat rate for each mile traveled within a jurisdiction. The onboard computer would calculate the fee and accumulate the total amount owed. The computer would read mileage from the odometer; the GPS input would be used to determine the jurisdiction in which the travel occurred so that the appropriate fee per mile could be applied.
- Periodically, the vehicle operator would communicate with a fee collection center to report the amount owed. The communication would be by a wireless connection or a smart card. Smart card readers would be attached to motorists' home computers or located at service stations or in other convenient places. In the same communication, the onboard computer's data file of rate information would be updated. The collection center would bill the operator and distribute the receipts among the participating jurisdictions.

The system would be capable of supporting more complex fee schedules, including charges that depended on the specific road and time of day. Such applications would be at the discretion of each jurisdiction and are seen in the proposal as a later development, after experience was gained with the flat rate mileage charge. Trucks equipped with onboard weighing devices (which are in commercial use today) could be charged fees that depended on road characteristics and weight. Identifying the road on which travel occurred would allow the state to set rates on state-owned roads and local governments to set rates on roads that they owned.

If the system incorporated a means of keeping track of the revenues generated by each road segment, this information would be likely to exert a strong influence on road capacity expansion decisions. However, applications that required uploading data from each vehicle on travel or fees owed by road segment might be seen as compromising privacy.

The proposal envisions a transition period of several years during which mileage fees and fuel taxes would be collected simultaneously. After a certain date, all new vehicles would be required to be equipped with the computer and GPS device; however, the authors judge that retrofitting the fleet of existing vehicles with the required equipment would not be feasible. Two technological options for avoiding double-charging of road user fees during the transition are suggested: devices on fuel pumps that would recognize when a vehicle being refueled was equipped for mileage charging and cause the fuel to be sold tax free, and an input to the onboard computer from a sensor measuring fuel added to the gas tank so that the computer could deduct fuel taxes paid in computing the mileage charge owed. The transition might proceed in three stages. In the first, all new vehicles sold would be equipped with the metering devices but only freight-carrying trucks and vehicles not paying traditional fuel taxes (i.e., hydrogen-fueled and electric

vehicles) would be charged mileage fees. In the second, all meter-equipped vehicles would be charged by the mile but collection of fuel taxes would be continued. In the final stage, all vehicles would be required to have meters and pay mileage fees (Forkenbrock and Kuhl 2002, 93, 100–102).

Toll Collect and Other Truck Mileage-Charging Systems

Aside from conventional toll roads, the only mileage-charging systems in effect today apply to large trucks. The truck weight–distance taxes in effect for a number of years in Oregon and other U.S. states, which rely on manual reporting of mileage, were mentioned above. Automated truck-charging systems are in operation in Europe. Trucks have been subject to mileage charges in advance of other vehicles for several reasons. As a commercial activity, trucking has always been regulated and monitored. For example, U.S. trucks are stopped routinely for checking of weight and registration and insurance documentation. Also, infrastructure costs directly attributable to truck traffic have long been recognized and quantified and, in the United States, reflected in user fees. These costs arise from pavement wear and bridge impacts, are proportional to mileage, and vary with vehicle and axle weights.

Some design features of the European truck systems may be applicable to general road use monitoring and charging schemes for all vehicles. The most significant implementation is the German Toll Collect system. (Toll Collect is the name of the private consortium of companies operating the system under contract to the German government.) Simpler systems are in operation in Austria and Switzerland.

Toll Collect measures distance traveled and collects mileage fees from trucks of over 12 tons loaded weight using the German Autobahn motorway system, a 7,500-mile network of roads with 2,500 interchanges that is managed by the national government. The Autobahns were conceived as a toll-free system, and the large number of interchanges renders traditional toll collection methods impractical. Annual travel of large trucks is 15 billion vehicle miles, of which 35 percent is by trucks operated by carriers outside Germany. Before 1995, foreign truck operators usually paid no German taxes, since they could purchase fuel in neighboring countries with lower fuel taxes and no other fees were imposed. In 1995, Germany began to collect permit fees from German and foreign truck operators as a member of the six-nation cooperative Eurovignette program (Kossak 2004). Toll Collect replaces the permit fees.

The operators of a truck using the Autobahn can equip it with an onboard computer with input from a GPS receiver. The computer uses the GPS position information to determine the vehicle's route and mileage on the Autobahn network and computes charges owed. The computer transmits data to a processing center via digital cellular telephone, and vehicle operators are billed periodically.

Eventually, 800,000 vehicles are expected to have the onboard equipment for automatic payment installed. Truck operators have the option of manually booking and paying the fee for an Autobahn trip.

Gantries spanning the motorway at various points record license plates and communicate with the trucks' onboard computers and the processing center to ensure that trucks are not using the motorway without paying. Vehicles with equipment to verify compliance are also employed for enforcement.

A consideration in selecting the toll collection technology was that it should be extendable to roads other than the Autobahns and to vehicles other than trucks (Kossak 2004). The system was constructed and is operated by a private firm under contract to the government. After overcoming some technical and administrative difficulties and delays, Toll Collect went into operation in January 2005.

The average toll is €0.124 per kilometer ($0.26 per mile) and varies with the number of axles on the vehicle and a pollution rating assigned to each vehicle. Revenue of €3 billion per year is expected (Kossak 2004). Rates varying with traffic volume are planned for later (CNT 2005, 2). Rates are to be set so that the total annual revenue equals the total cost to the road authority of serving truck traffic, as determined in a cost allocation study. Limiting revenues to road authority costs is in compliance with a 1999 European Union directive establishing a common policy on road use charges for goods-carrying vehicles (Sorensen and Taylor 2005, 99).

Revenue is dedicated to transport infrastructure: 51 percent for roads and 49 percent for railroads and inland waterways. A commission on infrastructure funding advising the German Ministry of Transport concluded in its 2000 report that "user charges can only be legitimized by the direct relationship between infrastructure use and the application of funds. Revenue from user charges should therefore normally be used in those infrastructure spheres for whose use the charges are levied. . . . The calculation of the level of user charges should be based exclusively on infrastructure costs" (Commission on Transport Infrastructure Funding 2000). The user charges recommended were mileage charges for trucks and, initially, periodic permit fees by operators of other vehicles. Although the commission was generally influential in setting government policy, the allocation of road user fees to waterways and railroads appears inconsistent with this recommendation as long as users of these facilities do not pay fees equal to costs. The effect of the revenue allocation also is questionable, since if the truck fee revenues actually approximate costs, then ultimately the road authority will need to replace the funds used for nonroad purposes (Kossak 2004).

Austria has operated a simpler system for collecting mileage fees since 2004. An overhead gantry has been installed on each of the 420 road segments between pairs of interchanges on the nation's 1,200-mile motorway system. Trucks and buses over 12 tons are subject to the toll and carry devices that communicate with devices on the overhead gantries. They employ a communication technique

known as DSRC (dedicated short-range communication). Vehicles passing under the gantries at normal motorway speeds are identified and their operators assessed charges corresponding to the road link and vehicle type. Charges are €0.13 to €0.273 per kilometer ($0.28 to $0.58 per mile), depending on vehicle type, and all revenues are dedicated to expenditures on the motorways (ASFiNAG n.d. a; ASFiNAG n.d. b). The Austrian system is essentially a large installation of an advanced version of the automated toll collection technology that has become standard on most toll roads. The design would allow toll collection to be extended to all vehicles on the expressways but generally is regarded as impractical as a means of assessing mileage fees on all roads because of the great number of stationary sensors that would be required.

Finally, the Swiss system, in operation since 2001, employs both DSRC (that is, short-range communications with roadside sensors) and GPS. Vehicles over 3.5 tons are assessed mileage charges for travel on all classes of roads in Switzerland. An onboard computer records the vehicle's mileage from the odometer. The computer determines mileage within Switzerland by sensing border crossings. It uses either DSRC with overhead gantries at major border crossings or position information from GPS to detect border crossings on minor roads. Operators must periodically forward the data recorded in the onboard computer to the road authority. Foreign operators who do not choose to install the onboard equipment must record and report mileage manually. Rates are higher than in Austria and Germany and are calculated to include a charge for environmental externalities as well as road authority costs (Sorensen and Taylor 2005, Appendix J).

Implementation Issues

Serious and credible technical proposals have been made for road use metering and mileage charging in the United States, and the essential components of such a system have been demonstrated in the truck mileage-charging schemes in operation in Europe. The U.S. proposals have been motivated by concern for the future viability of present funding sources as well as recognition of the benefits of pricing: more efficient operation of roads, better investment decisions, economies in the provision of capacity improvements, and avoidance of arbitrary or unfair distribution of the cost burden of road transportation. However, challenging problems remain to be solved before mileage charging could become the basis of U.S. highway funding. Among them are the following:

- Gaining public acceptance: It can be anticipated that the public and elected officials will be skeptical of a road use metering system that could be used by the government to track individuals' movements and activities. Road users who expect to pay more than they do under present charges or to be compelled to curtail their travel will also object, and the public and interest

groups will object if the new charging scheme is perceived as unfairly favoring some categories of road users over others or as increasing the disadvantages of the poor.

- Making the transition from present to new revenue sources: If mileage fee revenue is to wholly or partially replace revenue from present highway user fees, highway agencies will need to establish procedures for fitting vehicles and infrastructure with the necessary equipment, discontinuing collection of the old fees, and commencing collection of the new fees, with minimum disruption to revenues or inconvenience to travelers, over a transition period that may last a decade or more.
- Setting appropriate prices: Because of inexperience, highway agencies do not now have the competence to set mileage fees that maximize the benefits of the transportation system or to use the information provided by fee revenues to improve the payoffs from capacity expansions. Improper pricing practices could degrade system performance and harm the public welfare.

Appropriate technical design of metering and charging systems will be part of the solution to problems in each of these areas. For example, technical design features can help ensure privacy, the transition will be eased if systems allow users to choose to pay through either the old or the new charging scheme, and a system that is flexible enough to allow individual jurisdictions to set their own pricing policies and observe the results will speed the process of learning to set mileage fees. These three categories of problems and the problem of choosing a technical design are examined in the following subsections.

Gaining Public Acceptance

The likely objections to metering among the public and politicians are the same as those listed above with regard to toll roads: the scheme would be expensive and a nuisance, it would create perverse incentives influencing government transportation policy (e.g., increasing congestion could increase revenue), the fees would be unfair because they would be regressive and would reserve the best transportation service for the rich, and giving the government the capability to track the daily movements of all highway travelers is unacceptable.

Several analyses of the possible distributional consequences of road congestion pricing have indicated that the effects would be complex and would vary greatly depending on the nature of the pricing and road finance scheme, travel patterns and transit alternatives in the urban area, and travelers' occupations and household characteristics, and that a prediction that the wealthy would gain and the poor would lose would be an oversimplification (Santos and Rojey 2004; Safirova et al. 2004; Nash 2003; Sorensen and Taylor 2005, 58–60; Appendix C of this report). Nonetheless, there could be substantial numbers of people who found themselves

paying more and traveling less, at least in the early period of implementation of a congestion pricing program. Objections from this group could lead to failure of the program (Giuliano 1994, 273–276).

Road congestion pricing, especially pricing applied to nonfreeway arterial roads (as, for example, the Oregon road use metering proposal would allow), holds promise as a means to greatly improve the speed, reliability, and ridership of bus transit; reduce average costs; and generate sufficient new fare box revenue to pay for expanding transit service to meet increased demand. Transit gains would result from reduced road congestion and higher out-of-pocket costs for peak-period automobile travel, regardless of whether any road toll revenue was dedicated to transit (Small 2004). In addition, carpooling would become a more attractive travel alternative. These improvements would benefit lower-income households, and in some cities the benefits to this income group could be comparable in magnitude to losses suffered from being priced off roads or required to pay tolls (Kain 1994, 508–510).

Congestion pricing in urban areas would be a likely, but not essential, application of any future general road use metering and mileage-charging installation. Estimates have not been carried out of the distributional impacts of replacing or supplementing existing highway user fees with a mileage charge that could vary by jurisdiction but did not feature congestion pricing. Regardless of the exact character of impacts, planning for mileage charging should include identification of techniques to offset undesirable distributional effects without seriously eroding the potential benefits of the new form of charging (Nash 2003, 346). One possible solution would be direct compensation to low-income or other disfavored households. For example, transport vouchers that could be used to pay road tolls or transit fares could be distributed.

In defense of tolls and congestion pricing, it may be noted that present highway user fees may be regressive, if low-income drivers are likely to pay a larger share of their income for fuel tax and registration fees than high-income drivers [although the difference in shares among income groups may be small (Parry 2002, 31)]. If pricing is in effect, the motorist who chooses to pay the fee and use the road always gains in the transaction, since the use of the road is worth at least as much to him or her as the fee. Pricing can be regarded as fair in this sense.

The response to privacy concerns most commonly proposed is to construct the metering system so that the central facility is incapable of tracking individuals' travel. The Oregon and *New Approach* proposals both include such a design as an option: the onboard unit in each vehicle collects all information necessary to calculate the toll owed, and only this total amount need be transmitted outside the vehicle. This approach may be acceptable but has at least two drawbacks: enforcement and settlement of billing disputes might be more difficult than if detailed central records were kept, and information on the toll revenue generated by each segment of the road network would not be directly available.

Jurisdictions owning roads are likely to demand that mileage fee revenue be distributed accurately according to travel on each jurisdiction's roads. (Jurisdictional boundaries do not correspond to road ownership.) In addition, if jurisdictions had detailed information on the revenue generated by each road segment in their networks, they would be able to predict and observe the revenue effects of individual road improvements on their own or their neighbors' roads. Revenue impacts would influence investment choices and the evolution of the transportation system. This connection between demand and investment might be one of the most significant consequences of the metering and charging system.

The most direct and accurate way to determine travel by jurisdiction or road segment would be to maintain a central facility that collected information from vehicles on fee revenue generated by each road, but this practice would provide the facility with information about individuals' itineraries. An alternative that preserved privacy would be to provide the information by sampling, either by vehicle counts conducted independently of the road use metering system or by recruiting a sample of vehicle operators who would allow their movements to be tracked.

Ultimately, if public acceptance is attained, it will come about over time as the result of experience with various forms of road use charges on the part of the public and road operators. Development of conventional toll roads and applications of variable pricing and automatic toll assessment and billing systems are expanding and will be important sources of experience. Openness in the development process and demonstrations of effectiveness in early implementation will also be important in forming the views of motorists and the public.

Making the Transition

The Oregon Road User Fee Task Force and the *New Approach* proposals for conversion from the fuel tax to mileage charges both envision the need for a prolonged period during which fuel taxes and mileage fees would be collected simultaneously. Most motorists would switch from paying fuel taxes to the mileage fee only when they bought new vehicles with the necessary onboard metering equipment. In contrast, the German Toll Collect truck mileage-charging system appears to be on a faster track. Operators using the Autobahns regularly are installing the new equipment in their trucks, and most revenues will be derived from automatic metering and charging almost from the outset of the program. The transition task is far simpler for Toll Collect than it would be for the entire motor vehicle fleet of a state or of the United States (since Toll Collect involves only a small number of vehicles in a regulated industry), but the experience may contain some generally applicable lessons.

Two options that could speed the transition may merit exploration. First, retrofitting of metering devices on existing vehicles could be subsidized by the government out of user fee revenue. Second, fuel taxes could be abolished early in the

transition, after a short period during which all new vehicles sold would be equipped with road use meters, and replaced with higher annual vehicle registration fees for unmetered vehicles. Under this option, vehicle operators would have the choice of paying mileage charges or the flat fee. The European truck mileage-charging systems contain similar features. In Toll Collect, installation of metering equipment is free of charge to the vehicle owner and is funded from toll revenue. In Toll Collect and the Austrian system, trucks not equipped with the metering devices can travel on the expressways but must pay fees in advance. Similarly, the Oregon truck weight–distance tax provides for payment of a flat fee in lieu of the mileage charge. Transition alternatives are among the design issues that should be evaluated in pilot studies of road use metering and mileage-charging systems.

Retrofitting may be a poor option for automobiles, because the added equipment would be vulnerable to tampering. Equipment installed in new vehicles during construction could be made highly tamper resistant by using techniques similar to those that protect emissions control equipment from tampering today. The experience of Toll Collect will reveal whether retrofitting is practical for commercial vehicles.

The European experience also suggests that requiring operators of large trucks to undertake early conversion to road use metering would be technically and economically feasible as a step in the transition process. This would allow highway agencies to gain experience in managing the system before a general conversion occurred. The growing popularity of optional equipment in private vehicles that utilizes GPS and cellular communications could facilitate a transition to mileage charging. For example, General Motors has 3 million subscribers to its OnStar GPS navigation and communication system and has announced that OnStar will be standard equipment on all its vehicles sold in the United States by 2007 (General Motors Corporation 2005). Taking advantage of this trend may require development of standards defining the equipment capabilities necessary for the mileage-charging application.

Consideration of the challenges that the state of Oregon would face in implementing its proposal suggests that a single state would have difficulty adopting road use metering and mileage charging on its own. Out-of-state traffic and the high fixed cost of the onboard equipment would be problems. However, as part of a national program with federal leadership, one state might be compensated for start-up costs as a large-scale pilot implementation.

Setting Appropriate Prices

The Oregon proposal indicates how jurisdictions might approach pricing if given the option of mileage charging. The Oregon task force recommended a base fee for automobiles of $0.012 per mile (the present average state fuel tax revenue per mile of light vehicle travel) plus a charge to cover the state's added fee collection

costs (which the report estimates would be small under the proposed scheme). Higher per-mile fees would be charged during peak periods on all roads within the boundaries of urban areas, as congestion charges. The congestion charge could vary by hour of the day and by city, but not by road and not in response to immediate traffic conditions. Charges would be indexed to compensate for inflation (Road User Fee Task Force 2003, 31–41). The report does not address how the levels of congestion charges would be determined, but it mentions congestion reduction and revenue raising as goals, so presumably officials would set rates by trial and error to achieve a desired mix of these outcomes.

As noted above, the SR 91 Express Lanes in California have rates set so as to maintain free-flowing service at all times, because the facility is marketed as a premium alternative to the untolled lanes. Proposals for new HOT lanes or FAST lanes also incorporate this pricing practice.

Neither of these pricing rules—charging a flat base rate per mile to meet a revenue target or setting congestion fees so as to eliminate congestion—is likely to be the best from the standpoint of overall performance of the transportation system. The flat mileage fee may overcharge for some highway trips and thus needlessly discourage some worthwhile travel. Guaranteeing free flow on tolled lanes may divert so much traffic to congested lanes that the net benefit of the highway to all users is less than if brief periods of degraded service were tolerated on the toll lanes. Systematic experimentation and evaluation will be required to design fee schedules that maximize the public benefit from the roads.

It is not only ignorance that might lead to improper pricing. State or local governments with control of mileage fees would find that they had opportunities to extract monopoly profits from critical roads (Nash 2003), export traffic and congestion to neighboring jurisdictions (De Borger et al. 2005), or attract development from competing jurisdictions by underpricing of roads for certain categories of traffic. Such practices may be justifiable in some circumstances, but balancing competing interests affected by pricing decisions will be difficult.

If mileage charging comes into general use, the state and local authorities responsible for road construction and operation ought to control the pricing policy and revenue of the roads they own. It is unlikely that mileage charges could be implemented without adherence to this rule. Along with local control, some safeguards against improper use (that is, practices such as price gouging to gain local advantage at the expense of the general welfare) will be needed. Safeguards could include systematic monitoring, analysis, and publication of impacts of pricing decisions; development of national best-practice guidelines; and possibly creation of a regulator with authority to oversee roads as public utilities. The problem of inappropriate pricing policies could be lessened by aligning governmental responsibility for roads with the nature of the traffic. That is, local governments could be given control of roads carrying predominantly local traffic and states given control of roads carrying significant regional and interstate passenger or commercial traf-

fic. Privatization of the operation of certain kinds of roads could also help insulate pricing decisions from narrow or short-term considerations. (For example, a private operator would have no incentive to subsidize any class of user or exclude any user who was willing to pay the appropriate toll.)

Designing and Testing Options

The Oregon and *New Approach* proposals call for trials to evaluate the reliability, flexibility, cost, security, and enforceability of alternative designs for systems to monitor mileage and assess mileage fees. In addition to evaluating technological options, pilot studies should ideally be designed to gain information about the institutional requirements for administering such systems and about user acceptance and the cost and convenience of use. Evaluation of the behavioral impacts of mileage charges could be an objective, with appropriate research design, but it might be most practical to defer study of this question until after an initial stage of technological and institutional evaluations was carried out.

These goals imply that large-scale pilot studies will be needed that simulate as realistically as possible the important aspects of systems, including the setting of rates, the billing and collection of fees, enforcement, and the handling of system malfunctions. Pilot studies must follow scientific research design principles—that is, specific objectives, hypotheses to be tested, and evaluation methods must be defined at the outset.

Alternatives to government-led development of the technology of road use metering are conceivable. One such proposal, Certified Wide Area Road Use Monitoring, received some consideration in Australia and New Zealand (Malick 1998; Sorensen and Taylor 2005, 19). In this approach, government would publish performance specifications for a road use metering and mileage-charging system and allow private-sector firms to offer competing products and services to the public that meet the government's requirements and that might have additional utility to motorists. The firms could be made responsible for collecting fees and transferring them to the government.

A second necessary research track will be studies with the goal of providing guidance to highway agencies on the proper application and management of road use metering and charging systems. The starting point for this research should be evaluations of the growing number of road pricing systems now in operation. Among the topics the research should address are the following two issues: first, how road agencies are actually using pricing (that is, the goals, performance measures, and institutional constraints that are guiding their decisions about pricing, marketing, and other operational issues); and second, the impact of pricing on travel behavior and the costs and benefits of transportation systems. To address questions of possible impacts and management problems beyond those directly observable in existing road pricing implementations, modeling and simulation studies will be needed.

Finally, planning studies will be needed to lay out possible routes to widespread application of road use metering and pricing. The studies should address the responsibilities and relationships of federal, state, and local governments as well as the relationship of government to private-sector participants—developers of metering technology, motor vehicle manufacturers, and highway developers and operators.

SUMMARY

This chapter has surveyed options for changing the system of charging and paying for highways in ways that would improve the delivery of transportation services. The measures considered involve more direct means of charging road users, through tolls on limited-access highways and through metering and charging for use of all roads.

The potential of tolls assessed by the technologies presently in use in U.S. highway finance is limited: such tolls can be applied on only a fraction of the road system (i.e., to limited-access expressways), and therefore toll roads must always compete with untolled roads. A reasonable target for an ambitious program of toll conversion and new toll road development, following the models of the HOT networks and FAST lanes proposals, might be to raise additional revenue equal to the tolls already being collected on U.S. highways (that is, about $10 billion per year or less). Imposing tolls on all lanes of selected heavily traveled intercity routes (on the model of the existing turnpikes) could generate additional revenue, but this measure would be likely to face public opposition and is not receiving serious consideration. The net increase in highway budgets would be less than the added toll revenues because legislatures would be likely to adjust other fees to offset the new revenues. The following are among the possible benefits of a toll program on this scale: it could serve to concentrate spending on meritorious highway projects, it would improve traffic flow on the tolled facilities, and it might allow the public to learn about road pricing and decide whether more extensive application would be desirable. Attracting private-sector participation to the highway program by franchising toll roads could have public benefits as well.

Road use metering and charging systems offer great potential benefits to the public if the challenging obstacles to implementation can be overcome. There is a need for rigorous evaluations of options for the technical design of road use metering systems. More fundamentally, definition of the institutional framework for administration of mileage charges is at present undeveloped, and planning studies are needed on basic design questions: how fees should be set, who should control revenue and fees, the disposition of revenue, and the relation of revenue to transportation investment. One strategy for introducing road use metering is to start with a system for commercial vehicles. Some European road authorities have taken steps in this direction.

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Abbreviations

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ASFiNAG	Autobahn- und Schnellstrassen-Finanzierungs-Aktiengesellschaft
Caltrans	California Department of Transportation
CNT	Conseil Nationale des Transports
FHWA	Federal Highway Administration
GAO	General Accounting Office
ODOT	Oregon Department of Transportation
TxDOT	Texas Department of Transportation
VDOT	Virginia Department of Transportation
USDOT	U.S. Department of Transportation

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Finance Reform Proposals

Reforms Within the Present Framework

Chapters 2 and 4 examined two potential threats to the viability of present transportation program finance arrangements: decline of the tax base because of motor vehicle fuel economy improvements and erosion of the principles and practices, in particular user fee finance, that have been associated with the finance system's stability and success. Those chapters concluded that the present system shows signs of stress, and while it is not in immediate jeopardy of failing, improvements in pricing and financing practices probably will be necessary to slow or reverse deterioration of transportation system performance. In Chapter 5, examination of the prospects for tolls and mileage charges, alternative funding sources to replace or supplement the fuel tax, indicated that comprehensive implementation of satisfactory alternative road user charging mechanisms is still some years in the future. Because of the potential benefits of these alternatives, delay in developing them probably would be costly. Nevertheless, it will be necessary to continue to rely on present finance arrangements for most of the next 20 years and to take every opportunity to reinforce the proven features of the system, in particular, user fee finance in the highway program.

This chapter describes several kinds of finance reform measures that do not depend on developing major new revenue sources or on fundamentally altering institutional arrangements:

- Measures to increase available resources:
  - Reducing evasion and limiting exemptions
  - Indexing tax rates
  - Reforming use of debt finance

- Measures to improve pricing:
  - Refining user fees
  - Incorporating new vehicle technologies in the user fee structure
- Measures to direct spending more effectively:
  - Improving project selection and reducing project costs
  - Developing alternatives for transit finance
  - Redefining federal, state, and local government responsibilities

This list includes the short-term reform options in the state finance studies reviewed in Chapter 1, as well as proposals from other sources that have gained prominence. It was noted in the introduction to Chapter 5 that proposals from these sources tend to concentrate on particular aspects of the finance structure rather than on comprehensive reform. The descriptions in this chapter organize the proposals, somewhat arbitrarily, into three categories according to their main objectives: measures to increase available funds (including accelerating spending with debt financing), to improve pricing (that is, adjusting existing user fees to better match the costs of travel), and to guide spending more effectively to the best uses. In practice, many of the proposed actions could serve multiple purposes. For example, reducing tax evasion increases revenue but also is necessary for fairness and public acceptance and to maintain the integrity of the fee structure.

The subsections below describe the intent of each proposal and review available information about the possible consequences of implementing it, in order to identify those that appear to be practical and beneficial. Inclusion of a proposal in this list is not intended as an endorsement. Committee recommendations with regard to some of the proposals are presented in Chapter 7.

MEASURES TO INCREASE AVAILABLE RESOURCES

Reducing Evasion and Limiting Exemptions

Tax administrators have long recognized that a substantial amount of motor fuel excise tax revenue is lost to tax evasion. In a survey (Denison et al. 2000), state tax administrators reported their estimates that 5 percent of state gasoline tax revenues and 10 percent of diesel revenues are lost to evasion. Common evasion techniques reported were bootlegging fuel across state lines to take advantage of rate differences, taking advantage of the lower federal tax rate on gasohol by falsely labeling gasoline or a blend with less than 10 percent ethanol as gasohol, counterfeiting documentation of tax payments, and abusing tax exemptions (for example, exemptions for off-road and agricultural use). Diversion of aviation fuel (which pays a lower federal excise tax rate than diesel fuel for motor vehicle use) for use in diesel trucks is also recognized as an important evasion method. It reduces federal revenue by $900 million per year according to one estimate (Peters 2002).

Enforcement efforts in some states and by the federal government have had success in reducing fuel tax evasion. Methods include more intensive auditing, improvements in record keeping, and intergovernmental cooperation. Moving the point of tax collection upstream in the distribution chain also has been shown to reduce evasion (Peters 2002).

The 2005 federal surface transportation program reauthorization legislation [Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Section 1115] increases funding for enforcement of federal excise tax collections and requires upgrades in government records systems and other measures. The legislation includes a provision (Section 1161) intended to stop diversion of aviation fuel by requiring tax payment at the highway motor fuel rate for certain purchases of aviation fuel and requiring purchasers to apply for a refund with documentation that the fuel was used for aviation. Congressional estimates predicted $4 billion in additional revenue over 6 years as a result of the new enforcement provisions (Fischer 2004, 11).

Tax exemptions are a related drain on revenue. Federal and state fuel tax laws contain numerous provisions exempting classes of uses from liability for the fuel tax. Common exemptions are for government-owned vehicles and school buses. The special provisions of the federal excise tax on gasohol amounted to a partial exemption. (After changes in the law in 2004, the Federal Highway Trust Fund no longer loses revenue from these provisions.) Other loopholes include evaporation allowances for fleet purchasers. States commonly exempt fuel purchased for agricultural uses from taxation. To the extent that this fuel is actually used off public roads, this is not a violation of the user fee principle.

Certainly exemptions can serve legitimate functions. However, as the survey of tax administrators revealed, abuse of exemptions is a common form of tax evasion. A version of the 2005 federal surface transportation program reauthorization legislation before enactment contained a provision tightening requirements for documenting entitlement to exemptions. The provision was credited with significant revenue-generating potential (Fischer 2004, 12); however, it was not fully enacted.

Indexing Tax Rates

As Chapter 1 described, one of the most serious of transportation program administrators' complaints about present revenue provisions is that revenues are vulnerable to erosion by inflation because legislatures are slow to revise rates to maintain buying power. A few states have provisions allowing for administrative adjustment of fuel tax rates (see Chapter 2), but the rates in the majority of states and the federal tax rates can be changed only by legislation. Consequently, although revenues from cents-per-gallon fuel taxes and dollars-per-vehicle registration fees rise with increasing highway use, they decline with inflation until the legislature acts. It was

also shown in Chapter 2 that, although rate adjustments have been sufficient to maintain a fairly constant inflation-adjusted average user fee rate of $0.03 to $0.035 per mile, the timing of adjustments has been erratic and has lagged inflation. (See Table 2-3 and Figure 2-1 in Chapter 2.) This situation has complicated the administration of highway programs.

States have experimented with two mechanisms for removing this source of uncertainty and stabilizing revenues: replacing the cents-per-gallon fuel tax with an ad valorem tax (i.e., a tax that is a fixed percentage of the sale price) and indexing the cents-per-gallon rate. Under the second mechanism, periodic administrative adjustments are made to the rate proportional to the change in a specified measure of inflation, for example, the Consumer Price Index (CPI) or the highway construction cost and operating and maintenance cost indices compiled by the Federal Highway Administration (FHWA).

The greatest financial disruption experienced by transportation programs in recent decades was from about 1974 to 1982. During this period, high inflation, slow growth in travel, and the impact of the corporate average fuel economy standards in federal law combined to cause constant-dollar fuel tax revenue to decline by more than 50 percent (Table 2-3 and Figure 6-1). Several states reacted by enacting variable-rate fuel taxes. A review of this experience (Ang-Olson et al. 2000) found that the consequences were not satisfactory in several states. States that enacted ad valorem taxes in the 1970s saw revenues plunge along with fuel prices in the early 1980s, and states enacting such taxes in the 1980s, anticipating

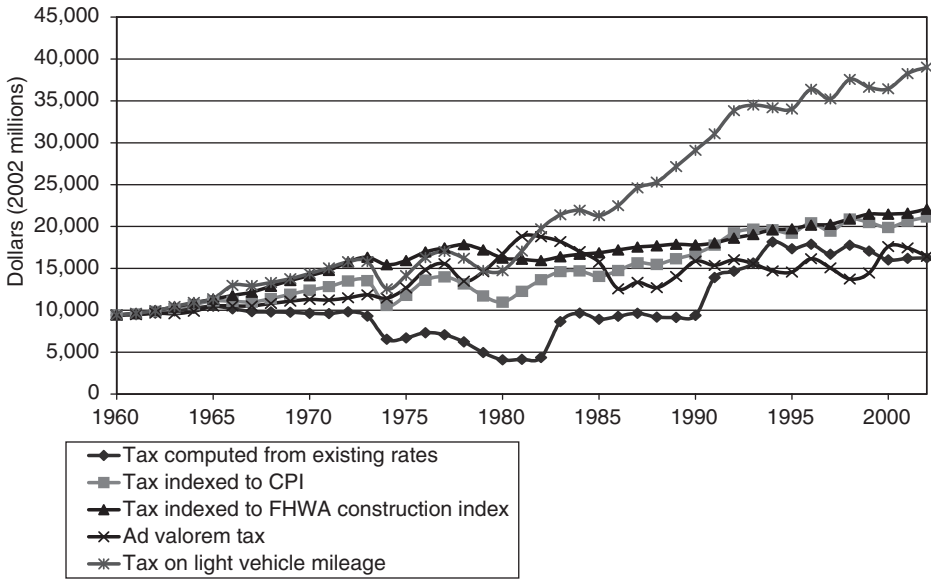

FIGURE 6-1 Federal gasoline tax revenues under various indexing methods.

a steady rise in rates, were surprised by the overall level price trend over the subsequent 15 years. Michigan tried an indexing formula in which the fuel tax rate was proportional to a highway maintenance construction cost index and inversely proportional to state fuel consumption. After the formula produced a 36 percent rate increase from 1982 to 1984, it lost political support and was allowed to expire. About 15 states tried indexing according to a variety of formulas in the 1980s, but most such taxes were rescinded because of public reaction and unpredictable revenue results. The review concluded that indexing to the CPI had proved to be the best way to keep revenue in pace with inflation and that limiting annual changes, by indexing an increment of the gas tax rather than the entire tax or by capping the annual change in the rate, would increase public acceptance.

Figure 6-1 shows annual constant-dollar revenue of the federal excise tax on gasoline since 1960 and estimates of annual revenues if the tax had been indexed to the CPI or the FHWA highway construction cost index in 1960. In the figure, revenues under the actual tax are computed as gallons of gasoline sold each year multiplied by the constant-dollar federal excise tax rate in the year, for comparability with the other curves in the graph. Also shown are revenues from an ad valorem tax on gasoline and from a light-duty vehicle mileage tax (at a cents-per-mile rate that rises proportionally to the CPI). Both start at rates in 1960 that would have yielded the same revenue as the actual tax. The revenue estimates take into account the probable effect of the change in the tax rate on gasoline consumption in each year.

The purpose of the estimates is not to show which tax rate scheme would have raised the most revenue. The differences among the various schemes in the absolute level of revenue in each year are not meaningful, because Congress would be expected to adjust the rate from time to time to yield revenue commensurate with its transportation spending plans. Rather than increasing total revenue, the intent of the variable tax rate would be to smooth out irregularities such as the decline in constant-dollar revenue from 1973 to 1980. Among the two tax indexing methods and the ad valorem tax, the CPI-indexed tax appears to be the most stable over the entire period. The construction cost–indexed tax rose rapidly until 1980 and more slowly than the CPI-indexed tax since then, but it also appears stable within those periods.

For Congress or a state legislature, the goal of authorizing indexing would be to ensure that the revenues it intended to raise were actually available, regardless of inflation. However, the legislature might oppose indexing if it believed that the practice would lessen its control over transportation programs because the state transportation department would be less dependent on the legislature's enactment of rate adjustments. The legislature might also be concerned about the public reaction to automatic tax increases. If indexing had the effect of insulating transportation programs from regular legislative review, the long-term consequence could be reduced political and public understanding of and support for these programs.

Reforming Use of Debt Finance

As Chapter 2 described, debt finance is little used in state highway programs (other than by toll authorities), and no trend toward greater use of debt is evident. In part, this aspect of financing practice reflects the structure of the federal-aid program, which has been the major funding source for most large highway capital projects over the past 50 years. Congress designed a pay-as-you-go program. It enacts multiyear authorizations to allow the states to plan, but the rate of disbursement of federal grants is governed by the rate of federal user fee collections (because the balance in the Highway Trust Fund is usually kept to less than 1 year's spending). On the basis of formulas, states receive annual apportionments, which must be used within a fixed period.

Debt financing allows state and local governments to complete a project earlier rather than postponing the project's benefits while waiting to accumulate funds or building it in increments. Borrowing also shifts some of the project's costs from present to future taxpayers or toll payers. Changes in the federal-aid program in the past decade have been aimed at facilitating borrowing. States may issue debt backed by anticipated federal grants [known as GARVEEs (Grant Anticipation Revenue Vehicles)], and federal law provides for the creation of state infrastructure banks (SIBs), revolving funds capitalized partially with federal grants that states and local governments can borrow from for highway construction. The programs are small compared with total capital spending: from their inception through mid-2004, 32 SIBs had issued loans totaling $5 billion, and 10 states had issued $5 billion in GARVEE bonds (USDOT 2004, 22–26; CBO 1998, x–xii).

A set of proposals for creating additional opportunities for use of debt finance was published in 2003 by the American Association of State Highway and Transportation Officials (AASHTO) (although not adopted as a policy of that organization) for consideration during debate over federal surface transportation program reauthorization legislation. The proposals included expansion of the SIB program and expansion of the existing Transportation Infrastructure Finance and Innovation Act program, which provides federal credit assistance to large public-sector transportation projects funded at least in part by user charges or other dedicated revenue sources (AASHTO 2003a). As described in Chapter 5, in the 2005 federal surface transportation aid reauthorization legislation (SAFETEA-LU), Congress did expand both of these programs, and it authorized use of tax-exempt private activity bond financing of toll roads.

The most ambitious proposal in the AASHTO document was for creation of a Transportation Finance Corporation, a federally chartered, nonprofit corporation that would issue $60 billion in tax credit bonds. The proceeds would be allocated by Congress in a manner similar to that in which federal highway and transit aid funds are now distributed. Tax credit bonds are bonds on which the interest is paid in the form of credits against federal income tax liabilities (CBO 2003). In

the Transportation Finance Corporation proposal, the general fund would be reimbursed for the tax cost of the program by transfers from the Highway Trust Fund (AASHTO 2003b). The objective of the proposal, which was not enacted, was to fund an immediate large increase in the federal-aid program. Proponents presumably saw tax credit bonds as a way to allow an increase in the program without immediately raising the rates of the federal fuel tax or other fees and without overtly breaking the link between user fee revenue and spending.

Tax credit bonds for transportation finance would have a number of drawbacks. They would allow spending before Congress had authorized highway user fees to pay for it. The bond scheme might pose a threat to the user-pays principle: if Congress failed to enact fees to cover debt service, then either highway spending for other purposes would have to be curtailed or the cost of the bonds would have to be shifted to the federal general fund. Tax credit bonds in general have been criticized on the grounds that their cost to the federal government is greater than if the funds were raised through conventional treasury borrowing. Furthermore, they tend to obscure the cost of borrowing in the federal budget if the issuing entity is not regarded as part of the federal government for budget purposes (CBO 1998).

MEASURES TO IMPROVE PRICING

Refining User Fees

Refinements within the present schedule of highway user fees or modest extensions to the structure could improve the performance of the transportation finance system. The objective would be to allow highway agencies to recover some costs that current fees do not fully recover and to provide incentives for more cost-conscious use of highways.

User fees, which were described in Chapter 2, include federal and state fuel taxes; state registration, license, and permit fees; the federal excise taxes on tires and on new heavy trucks and trailers; and the federal Heavy Vehicle Use Tax. These charges are imperfect as prices for road use because they do not correspond well to costs. For example, the fuel tax paid for operating a particular vehicle varies little from mile to mile, but the costs imposed by that vehicle on other users and on the highway agency vary greatly depending on the road and traffic conditions. Also, the fuel tax paid per mile depends on the vehicle's fuel efficiency, but costs probably vary little with vehicle size for passenger vehicles. Consequently, the fees paid for a particular trip can be much higher or lower than the actual cost of the trip to the highway agency and other road users. The fees will therefore discourage some valuable trips and fail to discourage trips that have small value to the traveler compared with their costs.

Annual vehicle registration fees have been criticized as a particularly unsatisfactory form of fee because they do not vary with miles of travel (Road User Fee

Task Force 2003, 23–24). However, registration fees do affect highway use by affecting vehicle ownership. Because of their simplicity and familiarity, registration fees can be a practical and worthwhile pricing mechanism. For example, many states charge truck registration fees graduated by weight to reflect the higher costs imposed by larger vehicles.

The special taxes paid by large trucks are the most important features in the present user fee schedule for aligning fees with the costs imposed by different users. Truck traffic is a major determinant of highway construction, maintenance, and operating costs. The characteristics of the largest trucks determine the design of pavements and roadway foundations; the strength requirements of bridges; the geometric design of grades, curves, and ramps; and maintenance costs for pavement and roadside appurtenances. The pavement wear caused by the passage of a vehicle axle increases proportionally to the third or fourth power of the load carried by the axle. Therefore, one passage of a 20,000-pound axle on a large truck will cause wear equal to several thousand passages of a 2,000-pound axle on a passenger vehicle. A large truck in congested traffic causes more delay than a car, and truck crashes on urban expressways are major causes of delay.

The federal government and the states periodically conduct highway cost allocation studies to determine their costs for providing roads for various kinds of vehicles. The studies face methodological challenges, but their results give an indication of the relative cost implications of truck and light vehicle traffic. The most recent federal study estimated that the revenue from fees paid by operators of combination trucks (a truck or tractor pulling a trailer, the principal highway freight vehicle) equals 80 percent of the highway agency expenditures attributed to this class of vehicle. However, the heaviest combination trucks were estimated to pay smaller shares of their costs than lighter combination trucks (USDOT 1997, Table VI-21). As noted in Chapter 2, combination trucks account for 5 percent of vehicle miles and pay 19 percent of all user fees.

The federal Heavy Vehicle Use Tax is intended to recover a part of the extra costs of serving large trucks. It is an annual fee of $550 on trucks with registered gross weight of 75,000 pounds or more and $100 to $550, depending on weight, on trucks of 55,000 to 75,000 pounds. The revenue from the tax is dedicated to the Highway Trust Fund. It raised $940 million in 2003, 3 percent of federal highway user fee revenue (FHWA 2004, Table FE-9). The rate schedule was last changed in 1984. The 1983 federal-aid highway act, which included a provision liberalizing federal truck size and weight limits, raised the top rate to $1,900 per year on trucks with gross weight of 80,000 pounds or more, rising in steps from $50 per year on 33,000-pound trucks. The adjustment corresponded to the findings of a U.S. Department of Transportation (USDOT) highway cost allocation study. However, the next year, following industry objections, Congress rolled back the use tax to the present rates and raised the diesel fuel tax to make up the revenue. Operators of large trucks also pay a federal excise tax on purchases of trucks,

trailers, and tires. The revenue, which is dedicated to the trust fund, was $2.1 billion in 2003, or 6 percent of federal user fee revenue. There is no federal excise tax on light vehicles.

Three possible refinements to federal and state user fee schedules merit consideration:

- Graduating the federal Heavy Vehicle Use Tax and state annual truck registration fees to correspond more closely to relative cost responsibility as indicated in federal and state cost allocation studies. Ideally, rates would take into account axle configuration as well as gross weight, because reducing loads per axle reduces pavement and bridge costs.
- Introducing a federal weight–distance tax. A few states charge trucks a tax that depends on weight and miles traveled. The Oregon tax produces the most revenue, $178 million in 2003 (FHWA 2004, Table MV-2). Oregon rates are from $0.04 to $0.185 per mile, depending on the truck's registered weight and number of axles (ODOT 2004). Fuel consumed by trucks paying the weight–distance tax is exempt from the state fuel tax. Truck operators must periodically report their miles and submit payments. A 1988 USDOT study commissioned by Congress concluded that a federal weight–distance tax would be feasible to administer because large trucks must already file federal tax reports to pay the Heavy Vehicle Use Tax, and reported mileage would be auditable because operators already keep mileage records to show compliance with state tax laws (CBO 1992, 21–23). The recent European experience with mileage charging described in Chapter 5 suggests that such fees may become standard there and that technology to automate reporting and fee collection is developing rapidly.
- Introducing a mechanism to align light-duty vehicle user fee payments more closely with costs. Larger light-duty vehicles pay higher average user fees per mile than do small vehicles because they consume more fuel, yet the cost of providing highways for these vehicles is not much greater than costs associated with the smallest vehicles. The 1997 federal cost allocation study estimated that the ratio of fees to allocated costs was 30 percent higher for pickups and vans than for cars (USDOT 1997, Table VI-21). One way to eliminate the discrepancy would be through adjustments in registration fees, although the impact of such a change would require study. The question of appropriate charges for small and large passenger vehicles is identical to the problem of deciding how future advanced-technology vehicles should be charged for road use, which is discussed below.

Any of these suggestions would encounter political obstacles. Truck operators successfully opposed the previous attempt to graduate the Heavy Vehicle Use Tax more steeply and have vigorously opposed weight–distance taxes for many years.

They have won repeals of these taxes in several states. They object that weight–distance taxes have high administrative costs and high rates of evasion, and they may believe that introduction of weight–distance taxes would be an occasion for increasing trucking's share of highway user fee payments. Criticism could be expected that adjustment of light-vehicle taxes would constitute a tax on energy conservation, and the adjustment would reduce revenue if fees for other vehicles were not increased.

None of the measures would be expected to yield large net revenues (although the financial impact of misalignment of truck fees with costs is growing because the volume of large truck traffic is growing faster than that of other vehicles). Their main justification is that they would improve the efficiency of the transportation system: truckers would have an incentive to operate equipment that reduced road wear, and highway travel by high-mpg vehicles would not be subsidized.

An evaluation of the Oregon axle-weight-distance tax (Rufolo et al. 2000) found that since introduction of the tax, a small increase has occurred in the average number of axles per truck in each weight class, which has reduced pavement wear costs. Because of data limitations, it was not possible to show that the tax was the cause of the trend in axle configurations. Under the Oregon tax, the fee per mile decreases with increasing number of axles on the truck within each weight class. Past Transportation Research Board policy study committees have argued that more significant savings for highway agencies and shippers could be attained by coupling axle-weight-distance taxes with less restrictive truck size and weight regulations, which would give carriers flexibility to optimize their equipment and operating practices (TRB 2002, 190–191).

Road Use Charging for Advanced-Technology Vehicles

Chapter 4 described the incentives that the federal and state governments are offering to promote alternative automotive propulsion technologies and high-mpg vehicles. Ideally, incentives would be structured to avoid accidental impacts on transportation finance (such as, for example, the impact of the federal gasohol tax preference). Also, because highway user fees function to an extent as prices reflecting the cost of providing roads, exempting owners of alternative-technology vehicles from payment of the fees discourages cost-conscious travel decisions. Whether they receive special subsidies or not, operators of high-mpg vehicles will pay less in user fees per mile of travel than operators of conventional vehicles as long as cents-per-gallon fuel taxes are the main component of the fees.

An incentive that subsidizes road use by forgiving payment of highway user fees can unnecessarily increase the cost of meeting the conservation or emissions goal. For example, if high-mpg cars are allowed free use of high-occupancy/toll (HOT) lanes, all other users of the highway will pay costs in the form of extra congestion caused by the free access or higher congestion tolls needed to keep traffic

flowing. For some trips, this cost to others (which should equal the toll the vehicle would have paid to use the HOT lane) will be greater than the value of the free access to the owner of the high-mpg vehicle. A cash subsidy—for example, a rebate of part of the purchase price of the high-mpg car—might attain the improvement in fuel economy at lower public cost, and the cost could be borne by all taxpayers rather than solely by other users of the expressway.

In recognition of these problems, California's Commission on Transportation Investment (whose report was described in Chapter 1) recommended taxing alternative fuels at rates such that vehicles consuming the fuels pay the same tax per mile as the average for gasoline vehicles (CTI 1996, 27). Excise taxes or registration fees would be other mechanisms for charging road user fees to operators of advanced-technology vehicles. In 2002, Oregon began charging hybrid vehicles a higher annual registration fee to make up for lost fuel tax revenue (Rufolo and Bertini 2003, 33), but fees were again equalized in 2003.

The 2004 federal legislation that restored the revenue to the Highway Trust Fund that had been lost on account of the federal gasohol subsidy set a precedent for structuring alternative fuel incentives so that transportation programs do not bear the brunt of the revenue impact.

MEASURES TO DIRECT SPENDING MORE EFFECTIVELY

Improving Project Selection and Reducing Project Costs

Avoiding spending on projects and activities that yield poor returns and economizing on project costs are means of augmenting the resources available to transportation programs. The report on state highway finance of the Citizens Research Council of Michigan described in Chapter 1 concluded that user tax increases would be justified only if they were accompanied by management reforms in the highway program: "Unless the system is restructured both financially and administratively, it is very likely that any additional dollars will not purchase the improvement in transportation services that might be expected" (Citizens Research Council of Michigan 1997, 5). The report's administrative proposals called for the following:

- Improved methods of determining priorities. "The state has no structure for systematically determining which construction or maintenance projects should be carried out in what order" (p. 12).
- Adoption of more durable designs and an increase in the share of funds devoted to maintenance, which, according to available data, would increase the cost-effectiveness of the program. The report concluded that the state does not know whether its design standards and maintenance practices minimize life-cycle costs.

- Increased contracting out and streamlined state–local cooperation to improve administrative efficiency.

The council's observations about decision making in Michigan are paralleled by the findings of a Government Accountability Office (GAO) review of state and local transportation investment decisions nationwide. GAO found that governments do perform various analyses of projects. However, there is no consensus understanding of the most useful methods, federal agencies provide only limited guidance on methods for the analyses that federal-aid programs require, and quantitative comparisons of benefits of alternatives play little role in decisions. The report acknowledges that other considerations, especially the availability of federal aid, public and political preferences, and constraints on intergovernmental cooperation, will exert major influence on decisions, but it concludes that the benefits of transportation investments could be increased through better use of analytical tools (GAO 2004b, 16–17, 39–40).

The report of California's Commission on Transportation Investment (also described in Chapter 1) contained similar recommendations for overhauling the state's planning and programming practices and for changes in state law to promote contracting out of certain transportation agency functions (CTI 1996).

A form of contracting that is attracting increasing attention as a means of reducing costs and accelerating schedules of transportation projects is the arrangement in which a private firm takes responsibility for design, construction, and often maintenance of a facility and bears part of the risk of cost or schedule overruns or performance failures. These contracts are commonly referred to as public–private partnerships (USDOT 2004; CBO 1998, xii). A USDOT review cites case studies showing that such contracts have reduced project costs by 6 to 40 percent, reduced the time to complete projects, and reduced the risk of cost overruns because of the performance incentives they provide to the private participants and the efficiencies of concentrating responsibilities for all phases of construction and operation (USDOT 2004, 2).

Developing Alternatives for Transit Finance

As described in Chapter 2, 10 percent of federal, state, and local highway user fee revenue was dedicated to mass transit in 2003, an amount equal to 25 percent of all transit spending. Highway user fee revenues devoted to transit in 2003 were as follows (FHWA 2004, Table HF-10):

Item	Amount ($ billions)
Distributions from the mass transit account of the Highway Trust Fund	4.7
Distributions from highway account of the Highway Trust Fund and devoted to transit	1.1
State and local highway user revenue devoted to transit	4.4

Total highway user receipts in 2003 were $104.1 billion (FHWA 2004, Table HF-10), and total public transit spending was $40.1 billion (APTA 2005, Tables 52 and 61). In addition to the highway user fee revenues dedicated to transit by federal law (and deposited in the mass transit account of the Federal Highway Trust Fund), transit receives funds from the highway account of the trust fund through the flexible fund program: states or local governments may use the grants they receive in two federal-aid program categories (the Congestion Mitigation and Air Quality Improvement Program and the Surface Transportation Assistance Program) for transit or highway purposes. In recent years, governments have devoted about one-sixth of the total funding available through these two programs to transit (FTA 2004).

Because the impetus for this study was concern for the viability of present highway user fees as a revenue source, the committee has considered transit funding only insofar as it is linked to highway user fees. Within this scope are two policy questions regarding transit finance: First, if a transition from fuel taxes to mileage charges and tolls takes place at some time, will it be appropriate to continue present practice and dedicate a portion of the revenues from these new sources to transit? Second, in the search for ways to cope with the threat of erosion of revenues (from inflation, improved fuel economy, or other causes) under present finance arrangements, should the link between highway user revenues and transit funding be modified? Modifications might increase or decrease the share of highway revenue available for transit. For example, increasing the flexibility of state and local governments to apply their shares of highway user fee revenues for nonhighway purposes might be expected to increase transit funding. In the other direction, replacing highway user fee revenue with another dedicated revenue stream for transit and retaining highway user fee revenue for highway purposes might be considered. Such proposals should be evaluated according to how they would affect the fiscal health of transportation programs and public acceptability of user fees.

In Chapter 3 it was argued that providing subsidies to transit can be justified by benefits conferred on highway users and that charging highway users fees that exceed the highway agency's cost of providing roads also can be a justifiable practice. However, the policy of dedicating a part of highway user revenue to transit does not in itself enhance the efficiency of the transportation system, compared with the alternative of providing transit subsidies from other dedicated sources or the general fund. The advantage of the policy is practicality. It has two important limitations. First, if highway user taxes are too high, the total public benefits of highway travel will be reduced. Second, if the effect of dedicating a portion of highway user fee revenue to transit is to decrease highway spending and increase transit spending, then the policy is beneficial only if the benefit of the increased transit spending is greater than the benefit that would have been derived from the lost highway spending.

After an evaluation of the trade-offs, one analysis of local transit funding options (Parry 2001) concluded that a mix of sources is necessary and that the capacity of highway user fees to support transit is limited. The possible revenue sources evaluated were the gasoline tax or other highway user fees, transit fares, the property tax, income taxes, and sales taxes. Raising property, sales, and income tax rates will cause economic dislocations that have costs. Raising transit fares will increase pollution and congestion from highway travel. Increasing the gasoline tax rate or other highway user fees would reduce pollution and congestion but also would cause the loss of some benefits of highway travel. The broadly based taxes (income, sales, and property taxes) have the advantage that relatively small increases in rates can generate large revenue relative to transit budgets.

This conclusion suggests that a reasonable policy may be to limit taxes on highway users for transit to fairly modest rates and to employ dedicated, broadly based taxes to support any expansion of transit programs. The present level of contributions at the state level—6 percent of all state highway user fee revenue devoted to transit—seems sustainable, although the federal contribution is much higher, at 17 percent (FHWA 2004, Table HF-10).

Many U.S. transit systems already receive support from dedicated, broad-based taxes. A 2004 report of the Metropolitan Washington (D.C.) Council of Governments' Metro Funding Panel concluded that a dedicated regional sales tax would be the most desirable and practical revenue source to make up the shortfall between existing revenue and the system's targeted spending level. The panel observed that the broad tax base (including visitors as well as residents) would match the breadth of the system's benefits and that a dedicated tax would provide needed revenue stability (Metro Funding Panel 2004, 6–8).

The practice of subsidizing a local service like transit with the revenue of a nationwide tax like the federal fuel tax may appear in the future to be especially difficult to justify. One proposal for a more essential role for the federal government in aiding local transportation programs would be to relieve local governments of the cost of serving nonlocal traffic on their roads (Gramlich 1990, 226–228). The arrangement could be similar to the so-called pass-through tolls that recent legislation authorizes the state of Texas to pay to the state's Regional Mobility Authorities—that is, payments would be made by the federal government to each local government proportional to the volume of nonlocal traffic on its roads. In return, local governments would accept responsibility for funding purely local transportation services. Compensation in the form of pass-through tolls would leave the local government in possession of the roads. This arrangement avoids the objection that local governments raised to Michigan's plan (described in the section above on federal, state, and local roles) to transfer major commercial routes to the state—that the local governments did not want to give up planning control over these components of their systems.

In summary, the following are some guidelines worth considering as the process of reforming highway user fees gives rise to needs for revisiting the relationship of highway and transit funding:

- The present rate of transfers of highway revenues to transit probably has small impact on highway programs, and highway travelers benefit where transit has alleviated congestion. However, greatly increasing the rate to fund expanded transit services would risk the loss of highway travel benefits that could be greater than the transit benefits gained.
- Transit requires stable and broad-based tax support. Developing and expanding such support will be necessary in order to expand transit services. Most transit agencies already derive some support from dedicated broad-based taxes. (For example, as Table 2-4 shows, 16 percent of funding in 2000 was from dedicated sales taxes.) However, these sources account for a minority of nonfare funding, and some jurisdictions make little use of them.
- Federal and state transportation aid ought to relieve local governments of the burden of serving nonlocal needs, rather than subsidize predominantly local services. Applying this rule would lead to some reallocation of external aid among American cities, but this outcome would be fair, since cities that were previously being undercompensated for the service they provided to interregional traffic would receive more aid.
- With effective road pricing, a substantially larger share of transit spending could be funded from fare box revenue. If at some time in the future true road pricing is instituted (for example, road use metering on all roads in metropolitan areas, with charges varying with traffic conditions), the economic justification for transit subsidies from highway user fees or other sources will be diminished. If each highway trip were charged the cost that that trip imposed on other road users and on the highway agency, highway travel would no longer be subsidized, and adding extra charges to pay for transit would reduce the economic benefit of the transportation system. Transit would increase ridership and would be able to charge higher fares because travelers would have to pay road user charges if they chose automobile travel.

Redefining Federal, State, and Local Government Responsibilities

The focus of the federal-aid highway program from 1956 until the 1980s was construction of the Interstate highway system. Since the completion of the Interstates, successive reauthorization acts have attempted to define new goals for the federal-aid program, and reauthorization debates have brought forth proposals for terminating or greatly scaling back the program. Support for devolution sometimes has come from states that historically have received less in federal transportation aid than the federal highway user fee tax revenues collected within their boundaries

(although certainly not all donor states can be associated with this position). In California, a state that currently receives 90 cents in federal highway aid per dollar of federal highway user taxes collected within the state and deposited into the highway account of the Highway Trust Fund (FHWA 2004, Table FE-221), the 1996 report of the Commission on Transportation Investment recommended that the state seek to have the federal government repeal the federal gasoline tax and return to California its share of the balance of the Federal Highway Trust Fund (CTI 1996).

Parallel debates have occurred at the state level with regard to the balance of responsibilities between state and local governments. For example, the highway finance reports of the Citizens Research Council of Michigan that were described in Chapter 1 proposed guidelines for a realignment of highway responsibilities between the state government and local governments, including state assumption of control of locally owned roads that were important through routes (Citizens Research Council of Michigan 1996; Citizens Research Council of Michigan 1998).

Before a local government could successfully take on any additional responsibility for transportation systems, it would need adequate funding sources and administrative capacity. The spending trends summarized in Chapter 2 show that nationwide, the scale of local government responsibility has not changed greatly in recent decades. However, the extent of local government responsibilities varies greatly. This diversity of practice suggests that alternative institutional arrangements are feasible. For example, although nationwide 19 percent of all road miles are owned by state governments, the state mileage is more than 60 percent of the total in five states (Delaware, North Carolina, South Carolina, Virginia, and West Virginia) and under 10 percent in 12 (including California, Florida, Michigan, and Washington). The great majority of local mileage is secondary roads and streets, and nearly all expressway mileage is state owned, but local governments own one-third of the mileage of urban arterial highways other than expressways.

Toll road authorities offer an institutional model for independent management of expressways on a metropolitan or regional level. Most toll roads in the United States are operated by independent authorities. The major turnpike authorities are subject to state political control, but locally controlled authorities operate toll roads in California, Colorado, Florida, Texas, and Virginia (FHWA 2004, Tables HM-10, HM-50, LGF-3B). The organization of local toll expressways in California, Texas, and Colorado was described in Chapter 5. Another institutional model is provided by the independent authorities, many of them organized on a metropolitan basis, that operate most large U.S. public transit systems. As Chapter 2 described, federal surface transportation legislation has promoted greater local government responsibility and capability for metropolitan transportation decision making; at the end of this section a proposal for federal action to strengthen these local capabilities is described.

The proposals outlined below, which were taken from several sources, are presented to illustrate the variety of conceptions of the extent of devolution that should occur and the scope of responsibilities that the federal government should retain.

Reorienting the Federal Program

These proposals concentrate on adjusting the rules and procedures of the federal-aid program to improve its performance in carrying out legitimate federal responsibilities. Under one reasonable definition of the scope of federal responsibility for highways, the federal government should ensure the supply of capacity that is beneficial from a national perspective but that state and local governments would not adequately supply on their own. State and local governments will have little interest in providing capacity to serve through traffic if it contributes little to local taxes and local residents' incomes.

Federal grants can fulfill this responsibility by paying state and local governments to supply the increment of capacity beyond their own requirements that would be beneficial for the nation as a whole. However, a long-standing criticism of federal-aid highway grants is that their structure provides little incentive for states to spend more on capacity than they would in the absence of the federal program. The state or local matching share is small (20 percent for most projects), and the total amount of federal grants for which a state is eligible is capped. Under these rules, if a state is undertaking more capital spending from its own funds than the minimum needed to match all available federal aid, then a large share of the federal aid probably is simply displacing state funds rather than adding to the net total of state capital spending (GAO 2004a; Gramlich 1990; Oates 1999).

A representative proposal for measures to increase the effectiveness of federal highway grants in fulfilling the core federal responsibilities of the federal government had the following provisions (Gramlich 1990):

- Roads serving predominantly state (or local) travel should be the responsibility of state (or local) governments.
- Roads with national significance should be eligible for federal aid; these roads could be identified according to the share of their traffic that is nonlocal or interstate travel.
- The federal matching share in highway grants should be reduced and the cap on available aid eliminated. For any project that a state undertakes on a road eligible for aid, the state should receive a federal grant representing the percentage share of out-of-state benefits. This share could be approximated by the percentage share of out-of-state traffic on the road and often would be small compared with the present federal contribution.

- Restrictions on the use of federal grants for maintenance should be eliminated so that decisions about the optimum mix of capital and maintenance spending on federal-aid roads would not be biased by federal restrictions.

A grant program following these rules would maximize federal leverage over the quantity of state spending on the eligible roads for a given total federal outlay, since all projects would be eligible for federal aid.

Comprehensive Devolution

Legislation proposed in Congress in 1996 (the Transportation Empowerment Act, *Congressional Record,* July 19, 1996: S8372), before enactment of the 1998 surface transportation act (the Transportation Equity Act for the 21st Century), and during debate before the 2005 legislation (SAFETEA-LU) would have phased out most of the federal-aid program over a period of years (Utt 2003). The elements of the 2003 bill (H.R. 3113, which was not enacted) were the following:

- The federal gasoline tax dedicated to the Highway Trust Fund would be reduced in five steps from the present $0.183 per gallon to $0.02 per gallon after 6 years.
- A category of essential federal highway programs would be retained:
  – The Interstate Maintenance Program, a federal categorical grant program now funded at $6 billion per year,
  – Federal spending for roads on public lands and Indian reservations,
  – Surface transportation research, and
  – Certain highway safety and motor carrier safety programs.
- During the transition period, the difference between spending each year on the essential federal programs and federal highway user fee revenues would be distributed to the states proportionally to tax collections in each state.
- Crediting of a portion of federal gasoline tax revenue to the mass transit account of the Highway Trust Fund would end immediately. A new, smaller federal transit grant program would continue.

Although such proposals have not progressed far, they indicate sentiment, particularly among officials in some states that contribute more federal highway user fee revenue than they receive in federal aid. The National Surface Transportation Infrastructure Financing Commission created in the 2005 legislation (SAFETEA-LU, Section 11142), is to evaluate, as part of its charge, a proposal to allow any state not to participate in the federal-aid highway program in return for a suspension of federal highway user fee collections within the state.

Empowering Local Governments

The underlying rationale of devolution proposals is that most highway and transit problems are primarily local in their scope and impacts and that therefore the federal government lacks competence to solve them. A series of proposals published by the Brookings Institution calls for devolution of decision making and revenue raising, but with active federal engagement to realign authority in favor of local governments relative to the states (Boarnet and Houghwout 2000; Puentes 2004). The highlights of these proposals are the following:

- The federal government should provide financial incentives for states to transform metropolitan planning organizations (which are creatures of federal transportation programs) into regional infrastructure authorities, with taxation, programming, and spending power, and to tie state decisions more closely to the priorities of metropolitan governments.
- Most federal funding should be replaced with regionally levied user fees.
- The retained federal responsibilities should be
  - Preservation of portions of the network that provide truly national benefits,
  - Provision of assistance to poorer regions,
  - Cooperation with states and metropolitan governments on standards setting and research, and
  - Environmental protection.

SUMMARY

This chapter has surveyed options for adjustments to the system of charging and paying for highways and transit in ways that would improve the delivery of transportation services. The measures described have been prominent in discussions of transportation finance reform. They include a variety of adjustments to existing charges and changes in management practices, which their proponents believe would augment resources, better align fees with costs, or improve the effectiveness of transportation spending, and which could be carried out without fundamentally altering the existing framework of user fees and revenue sources.

Among the measures listed, several appear to hold promise for improving the stability of transportation funding and the performance of the transportation system. They include adjusting fees according to the cost of providing service to different kinds of road users, in particular, large trucks; improving tax compliance and limiting exemptions from payment of user fees; providing additional dedicated funding sources for transit; and better aligning the responsibilities of federal, state, and local governments with the character of the transportation services provided. Committee recommendations for actions on some of these measures are

presented in the next chapter. Individually, none of these measures would dramatically affect user fee revenue or system performance. Nevertheless, striving for small gains on multiple fronts may be the most productive short-term strategy available to governments that operate highways and transit.

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
CBO	Congressional Budget Office
CTI	Commission on Transportation Investment (California)
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GAO	Government Accountability Office
ODOT	Oregon Department of Transportation
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

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Conclusions and Recommendations

The committee has assessed the future revenue-generating prospects of present highway user fees. It has considered possible threats to the viability of these revenue sources from a decline in the tax base and from declining adherence to the user fee finance practices that were basic to the system at its origin. The committee also identified reforms for the highway and transit finance systems that are worthwhile regardless of the future revenue potential of the present system of highway user fees. In considering options, it focused on how finance arrangements can affect the performance of the transportation system through their influence on the decisions of travelers and on government investment and management decisions. The committee gave special attention to methods of charging fees that could be directly related to the cost of providing services, in particular, tolls and mileage charges.

The conclusions presented below address the viability of present revenue sources, the merits of present transportation finance arrangements, and the potential value of various reform options. The committee's main conclusions are italicized. The recommendations propose immediate changes to strengthen the existing highway and transit finance system and actions to prepare the way for more fundamental reform in the long term.

CONCLUSIONS

1. Viability of Revenue Sources

As the term is used here, a viable funding arrangement is one that will retain the capacity to fund transportation programs at an inflation-adjusted rate comparable with that of the past 20 years. In that period, revenues were sufficient to fund growth in highway spending and capacity and some improvements in service but not to prevent growing highway congestion.

According to this definition, the failure of the arrangement to raise revenue sufficient to fund any defined level of needs (for example, as identified in the highway needs studies of the states and the federal government) is not in itself evidence that the arrangement is not viable. Tax rates and total revenues generally reflect the judgments of legislators and voters about priorities, and the existing set of user fees would have been suitable for generating substantially higher or lower revenue in the past if legislators had chosen to do so. However, if the present funding arrangement had structural features that were causing it to become ineffective as a revenue-raising mechanism, its viability would be questionable.

The committee considered the gravity of two kinds of possible structural problems that may pose threats to the viability of the established funding arrangement. They are, first, that changes in automotive technology, rising fuel prices, or new energy or environmental regulations may greatly depress gasoline and diesel fuel consumption and therefore revenue from fuel taxes and, second, that the user fee finance principle that has been the basis of highway finance may be eroding in practice, as indicated by a proliferation of new applications of user fee revenues and growing dependence on revenue from sources other than user fees.

Loss of the Tax Base

A reduction on the order of 20 percent in average gallons of fuel consumed per vehicle mile by the light-duty vehicle fleet is possible by 2025 if fuel economy improvement is driven by new regulations or large and sustained fuel price increases. Offsetting the revenue effect of a gain of this size would not require fuel tax rate increases that were extraordinary by historical standards, although the willingness of legislatures to enact increases may be in question. In the absence of new regulations, fuel price increases alone probably will stimulate only a small improvement in fuel economy in this period. After 2025, large market shares for hybrid electric and fuel cell–powered vehicles, and consequently greater reductions in gasoline consumption, are possible, if driven by government intervention or high fuel prices.

This assessment of prospects for fuel economy improvement may seem too modest in light of recent circumstances. Sharply higher fuel prices in 2005 added to concerns about energy supplies and the environmental cost of fossil fuel combustion. At the same time, promising technological developments, including commercially popular hybrid vehicles and progress on fuel cell power, create a potential for a substantial reduction in gasoline consumption in the long term. (For example, in the fuel economy projections and scenarios reviewed in Chapter 4, a 25 percent improvement in fleet average fuel economy is achieved sometime after 2025.) The committee based its conclusion on its review of projections from several sources that considered the state of automotive technology and the history of response of consumers to fuel price changes and technological advances. Three factors will constrain the rate of progress on fuel economy. First, consumers have

shown strong preferences for maintaining or enhancing the performance and size of the vehicles they buy, and they take advantage of the savings afforded by fuel economy improvements during periods of fuel price stability by buying larger, better-performing vehicles. Second, new vehicles that offer performance and cost close to today's vehicles with significantly lower fuel consumption will require time to be brought into production. Finally, the stock of vehicles on the road turns over slowly (about 6 percent of the fleet is retired annually, although high fuel prices may accelerate turnover). From 1971 to 1991, a period that saw the energy crisis of the 1970s, dramatic spikes in fuel prices (e.g., a doubling in current dollars from 1978 to 1981), and the implementation of rigorous new federal fuel economy regulations (starting with 1978 model year cars), fuel consumption per mile for the light-duty fleet was reduced by 33 percent. A reduction of this magnitude was possible because the automobiles of the day were relatively inefficient. Similar events would be unlikely to provoke the same amount of saving today.

The Department of Energy projects that by 2020 world oil producers will be able to expand output by 30 percent and that U.S. motorists will be able to increase travel by 33 percent without forcing the price of gasoline much above the $2 per gallon level (in 2004 dollars). This is consistent with projections of petroleum prices from other sources. The rationale of the projections is that the rate of oil price increase since 2003 will not continue. Large supplies are available from multiple sources that can be developed and brought to market at lower cost than the 2005 price, and maintaining the price of oil too high is not in the long-term interest of the major producers since it encourages conservation and stimulates development of alternative sources. The projections take into account rapid growth in oil consumption in China, India, and some other developing economies. For example, in the Department of Energy's reference case projection, oil consumption in China grows at more than twice the world rate and China's share of world oil consumption increases from 8 percent in 2004 to 11 percent in 2020. This outlook does not factor in the risk that political events will disrupt supply. Energy forecasts are speculative. However, there are grounds for expecting that, even if the relatively high prices of 2004–2005 persist, output will increase sufficiently to moderate the long-term price trend. Fundamental changes in fuel economy and engine technology are possible in the next two decades. Nonetheless, the implication of the projections the committee reviewed is that if such changes occur, they are more likely to be the result of government intervention than of energy market developments.

Erosion of Established Finance Practices

Government transportation finance practices have been remarkably stable and resilient since the creation of the present federal highway program in 1956. However, some potential sources of stress are evident, particularly in states where the local share of

responsibility is high. Sources of stress include pressures to expand use of highway user fee revenue for nonhighway purposes, the growth of transit spending as a share of local transportation spending coupled with the lack of a stable basis for transit funding, and vulnerability of revenues to acceleration of inflation.

In the original conception of the federal-aid highway program and the similar highway finance schemes that most states adopted, finance practice was defined by simple rules: highway users paid special fees, fee revenue was dedicated to highway spending, and the revenue was sufficient to cover government outlays for highways. This arrangement enjoyed political and public support. It was considered to be fair because users paid the government's cost of providing highways and was considered to be an effective way of matching government spending to taxpayers' preferences because users could identify the benefits that they received from their payments and because spending was limited to a level that users were willing to support. If adherence to these practices were to decline and no new consensus principles emerged to take their place, there would be grounds for concern that the stability and direction of transportation programs were threatened.

To assess whether adherence to traditional finance practices is declining, the committee examined trends in the application of user fee revenue to nonhighway purposes, reliance on revenue from sources other than user fees to fund transportation, and devolution of transportation responsibilities to local governments (since local governments usually have not had direct access to fuel taxes and other instruments for charging highway users). The conclusions are presented below. In summary, the examination revealed that national average user fees per vehicle mile, fraction of highway spending covered by user fees, and fraction of highway user fee revenue devoted to nonhighway purposes have changed little in the past 25 years, but that the average hides a diversity of experiences among the states.

Nonhighway Application of Highway User Fee Revenue Regardless of the merit of the practice of dedicating highway user revenues to transit or other nonhighway purposes, growth in such uses of revenues would affect the viability of the transportation finance system if it subtracted too much from highway spending or weakened support for user fees among highway users. The question of concern is not the intrinsic worthiness of public investment in transit and other nonhighway applications of highway revenue, but solely whether expanding application of the revenue for such purposes may threaten the integrity of established transportation finance arrangements.

The funding of federal transit aid with fuel tax revenue is the most important dedication of highway user fee revenue to nonhighway purposes. Today about 17 percent of federal highway user revenue ($6.0 billion out of $35.1 billion in 2003) is dedicated by federal law to nonhighway uses. In addition, states and local governments devote about 4 percent of aid funds they receive from the highway account of the Federal Highway Trust Fund to transit ($1.1 billion out of $30.3 billion in 2003).

State highway user fee revenues dedicated to state transit programs or transit grants ($3.8 billion in 2003) equal about 5 percent of state government highway spending ($80.2 billion in 2003). In certain states, portions of highway user revenues are dedicated to nontransportation purposes, but states also devote funds from nonhighway sources to highways. In national totals, state revenues from highway users nearly equal the states' highway spending: the sum of all state-imposed highway user fee revenues and federal highway aid received by states was $93.4 billion in 2003, and current spending by states for highways plus state grants for highways to local governments was $92.0 billion. However, the balance between revenue and spending varies from state to state.

Reliance on User Fee Revenue and Devolution to Local Governments

The committee examined whether reliance on user fees to fund transportation has declined and whether the local government share of financial responsibility has been growing. Significantly declining reliance on user fees would be a fundamental departure from historical practice and would necessarily call into question the viability of the fuel tax and the other user fees. Whereas state government highway programs are predominantly funded by state-imposed user fees, local governments historically have paid for their shares of transportation expenditures out of general revenues or with dedicated broad-based taxes (e.g., dedicated sales taxes or property taxes). Local jurisdictions may lack legal authority to impose fuel taxes or vehicle fees, and motorists can easily avoid a local fuel tax if neighboring jurisdictions have lower rates. In some instances, a local property tax assessment dedicated to streets or to infrastructure may function much as a user fee, for example, in a suburban residential community where the streets to be maintained are primarily for local access, there is little through traffic, and household characteristics are somewhat uniform.

Devolution of responsibilities to local governments would in many circumstances be in the public interest if it were accompanied by adequate funding provisions. However, it will also strain traditional finance practices if local governments do not have access to and control over user fee revenue. Many local jurisdictions operate arterial roads that serve nonlocal traffic and are subject to congestion and that would be funded most appropriately by user fees.

When highway spending and highway user–derived revenues alone are examined, neither devolution of responsibility to local governments nor decline in the ratio of user revenue to expenditures is evident in national totals. The local government share of highway spending has averaged about one-third since the 1960s and has been fairly constant. The ratio of highway user fee revenues to highway spending for all levels of government combined has fluctuated around 80 percent since the 1960s.

However, in the past 15 years, the local share of total government highway and transit spending has increased, and the ratio of user fee revenue to total highway and transit spending has declined. The trends are not dramatic in national

totals but are pronounced in some states. These trends, where they are occurring, are related to the growth of transit spending. Transit depends more on aid from local sources than from the state or federal governments and covers only a minority of its expenditures with user fee revenue.

Legislative Support of User Fee Finance As the introductory chapter explained, the committee did not estimate how much governments should spend on highways. Legislatures and voters are competent to decide on transportation spending levels, taking other priorities into account. Therefore, failure of legislatures to set rates high enough to raise revenue sufficient to satisfy some predetermined level of needs is not in itself evidence that the present funding arrangements are dysfunctional.

However, an unwillingness by legislatures to maintain revenues because of inherent, particular characteristics of highway user fees could be viewed as bringing into question the viability of the present fees. For example, the structure of fees might come to be regarded as unfair, or fuel taxes might become especially unpopular because of the rapid rise of fuel prices. Under these conditions, the fee scheme could be regarded as structurally impaired as a revenue-raising instrument. The impairments might be overcome by introducing new forms of fees.

The committee does not have evidence that any such structural characteristics of highway user fees are discouraging legislatures from adjusting the rates. The following observations are evidence to the contrary:

1. Legislatures are adjusting rates sufficiently to maintain constant average revenue per vehicle mile and to expand capital stock (although not sufficiently to keep congestion from increasing). The frequency of state rate increases was much greater in the 1980s than in the 1990s, but the cumulative impacts of rate changes during the two decades were equivalent—that is, average rates just about kept up with inflation. At the federal level, rates have not changed significantly since 1993, but Congress has acted twice since then to increase deposits to the Highway Trust Fund. The practice of depositing part of fuel tax revenue to the general fund was eliminated, and the federal revenue loss caused by the gasohol subsidy was debited to the general fund rather than the trust fund.
2. Since the 1980s, the growth rate of state highway user fee receipts has been slower than the growth rate of all state tax revenues, but only moderately so (84 percent versus 104 percent in constant dollars from 1981 to 2001). During this period the extent of state government responsibilities was expanding in many domains. Thus, the funding constraints on highway programs appear similar to constraints that all state programs faced in this period, rather than problems inherent in the structure of highway funding.

It has sometimes been asserted that growing use of highway user fee revenue for nonhighway purposes has undermined support for tax increases. In some cases this consideration may have been decisive; however, the share of revenues at the state level that is dedicated to nonhighway uses is small enough on average that the practice seems unlikely to have had a major influence overall.

Resistance to raising fees may stem in part from poor performance of some highways and a public impression that expansions buy little improvement. Reform of finance could enhance performance and increase the visible improvement produced by system investments. This outcome might cause legislatures and voters to adjust their spending preferences in favor of transportation.

2. Merits of the Present Finance System

The finance system probably has contributed to the success of the highway program in delivering a positive return on the national investment in highways. User fees discourage motorists from making trips of little value, spending has been constrained by the revenues generated from users, and the system allows taxpayers to see the cost of providing highway services. The system also has important shortcomings.

The viability of the finance system is of concern only if the transportation programs it supports are beneficial and present finance arrangements help these programs to perform effectively. The system has influenced the behavior of users and the agencies providing services and consequently the economic return on transportation investments. The committee examined the available evidence concerning whether these influences have been positive.

Available estimates are incomplete but indicate that the nation has earned a positive return on the investment in the highway system, that historical annual expenditure levels have been justified by the incremental benefits received, and that opportunities exist for expansions that would yield high payoffs. The finance system probably has contributed to this success. To a limited extent, existing user fees discourage motorists from making trips that they value little in comparison with the cost of providing them. These fees are about 7 percent of the cost of operating a motor vehicle and vary with use.

More significantly, the revenues generated from users impose a constraint on spending. Reliance on dedicated revenue from user fees reduces the risk that total spending will greatly exceed justified levels, since it is unlikely that the revenue would sustain a facility that produced low levels of benefits for users in relation to its costs. Also, in the political process of setting highway budgets and fees, users are unlikely to support fee levels beyond those that benefit them or to support projects that yield low returns. There is, however, a danger that interests that gain from construction spending regardless of user benefits or fee levels will lobby for fees that are higher than justified.

The practice of dedicating the revenue from a particular tax to a particular use also provides revenue stability (compared with reliance on annual appropriations

from the general fund), which is valuable for a public works program that entails long-term commitments. Stable funding eases public- and private-sector borrowing to build facilities. A further pragmatic justification for the practice may be that it has appeared in some instances to be effective in gaining public assent to a tax increase in support of a specific program, even during this era of antipathy to other tax increases.

Gaining the efficiency benefits of charging fees to highway users does not require that the revenues raised be dedicated to highways. User fees are beneficial as long as they induce savings in the costs of highway travel (for example, congestion, pollution, or road wear costs) that are greater than the value of lost travel benefits to highway users who forgo or alter travel because of the fees. However, dedication of revenues appears, in practice, to have exerted a degree of discipline that has tended to keep spending within bounds and to direct it to worthwhile projects, and that would be absent if there were no linkage between spending and the tax and fee revenue raised from users.

Transportation programs also have important failings related to the structure of the finance system. The system does not provide a strong internal check that individual projects are economically justified. Such a check would exist for projects that were financed with funds they generated themselves. Fees do not correspond well to costs. Some road users, including operators of certain types of trucks and buses, do not pay fees commensurate with the pavement and bridge wear costs that they impose on highway agencies, which encourages inefficient use of highways. Because fees do not vary with traffic conditions, avoidable congestion costs are tolerated. The present level of benefits of the road system could be attained at lower cost if pricing were improved.

3. The Value of Reform

The conclusions above indicate that the risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years. That is, the system should be able to fund growth in spending and capacity, although not at a rate that will reduce congestion. However, transportation system users and the public could benefit greatly from transition to a fee structure that directly charged for actual use of roads.

No likely developments in motor vehicle technology, energy price, or regulation will have an impact on revenue in this period that could not be offset by rate increases that are within the range of historical precedent. There could, however, be lags in adjusting to the revenue consequences of high inflation or a large increase in the price of fuel.

Transitioning to direct charging (for example, a system that charged according to mileage and road and traffic conditions) in place of present user fees would potentially have two benefits:

1. Improved operation of the road system, including reduced congestion. By inducing some travelers (those who place a relatively low value on traveling during the peak) to avoid congested time periods, pricing can reduce congestion and trip times for the remaining travelers. Experience with peak charging on roads in the United States and other countries has demonstrated its effectiveness for controlling congestion. Prices must be set so that the benefits to those who enjoy faster travel exceed the cost of inconvenience to those who are induced to change travel habits.
2. Better targeting of investment to the most worthwhile projects. If such a road charging scheme were in effect and highway spending depended on revenue from the fees, expenditures would tend to be directed toward parts of the highway network that generated revenues sufficient to pay for improvements. Pricing would affect investment decisions through several mechanisms:
   – Revenues from peak charges and the response of traffic to the charges would accurately indicate the value the public places on individual highway facilities and would reveal the locations where capacity expansions would have the greatest benefits.
   – Revenue impacts would influence investment decisions: projects with the potential to generate net revenue increases sufficient to pay for themselves would be more likely to be constructed.
   – Because local governments would expect to control the revenues generated by the roads they owned, growing regions with high congestion would generate high revenue and would retain that revenue to support regional needs.

However, highway agencies will need new technical skills to take advantage of the information provided by pricing, and oversight may be needed to prevent abuse of pricing powers.

There is no certainty that finance reform in the direction of improving the efficiency of the transportation system would raise more revenue than existing arrangements. However, reform would make transportation dollars go further, and it is conceivable that the public would be willing to invest more in a transportation system that worked better.

Many years of coordinated effort will be needed to develop the technical and institutional capabilities required for reform and to demonstrate to the public that the potential benefit is genuine. Therefore, an early start is essential.

4. Principles for Reform

Reform of the finance system would have benefits now. Eventually, the deteriorating performance of the transportation system and the growing cost of

maintaining acceptable service under present practices may compel reforms that would increase efficiency. *As the system evolves, adhering to the following rules will help keep it on a course leading to the necessary improvements.*

- *Maintain the practice of user fee finance,* that is, a system in which users of facilities are charged fees or special taxes, payments reflect the transportation provider's costs to serve each user (to the extent that is allowed by the fee structure), and expenditures to construct and operate the facilities are equal to the fee revenue. The last condition implies dedication of user fee revenue to transportation programs.
- *Seek opportunities to apply pricing where possible.* Pricing means allowing fees to ration access to a service or facility. Pricing could significantly lower congestion and other highway operating costs. Two examples of pricing that could be applied immediately are variable tolls on toll roads or lanes (with higher charges imposed during peak periods) and the charging of trucks for the pavement wear they cause. Such initial steps would yield benefits in their own right and would be an opportunity for administrators to learn to apply pricing and for the public to observe its consequences.
- *Align responsibilities of the federal, state, and local governments so that the recipients of each government's services correspond as nearly as possible to its constituency.* For example, local governments should have primary responsibility for providing and funding facilities that serve mainly local travel of their own residents, and states should be responsible for serving intercity and regional traffic. In this way the voters overseeing tax and spending decisions will be those directly bearing the costs and receiving the benefits. The organization of transportation programs today often departs from this rule, in part because local governments are limited in their ability to collect user fees. A goal of reform should be to allow each jurisdiction to collect fees from all users of its facilities.
- *Undertake reforms with full awareness of environmental and equity consequences.* In planning for finance reform, governments should identify techniques to offset undesirable distributional effects without seriously eroding the benefits of new forms of charging. Possible solutions include direct compensation to low-income households or other disfavored groups (for example, distribution of transport vouchers that could be used to pay road tolls or transit fares) and expansion of transportation services important to these groups. Provision of additional transit service where the service would be of value to persons displaced by peak highway charges could mitigate the equity consequences of finance reform involving pricing. (The distributional impacts of improved pricing will not always be undesirable. For example, road pricing in cities could cause gains in transit service quality and revenue, which would benefit the transit-dependent population.)

Reform that involved partially or entirely replacing fuel taxes with other forms of charges would reduce the price of gasoline (not necessarily by the full amount of the tax reduction) and lessen motorists' incentives to choose more fuel-efficient vehicles. If fuel taxes are reduced in the future, the impact on fuel consumption should be recognized and consideration given to the need for offsetting actions, if the outcome appears contrary to the goals of U.S. energy policy. A system of mileage fees that incorporated congestion charges would have broad impacts on energy consumption through its impact on congestion, travel, and land use.

Efficiency requires that users of the transportation system take into account the environmental costs of their travel choices. One way of accomplishing this would be to impose charges for pollutant emissions. However, the best results from a pollution-charging scheme would be obtained by subjecting all emissions (from transportation and nontransportation sources) to equivalent charges. Broad-based taxes applied equally to all petroleum consumers would be the most cost-effective in promoting petroleum conservation. The distributional and environmental impacts of major changes in transportation finance practices will not be fully predictable. It will be necessary to observe consequences systematically and make adjustments when undesirable side effects appear.

5. Reform Opportunities

The committee considered two kinds of proposals to overhaul the system for charging highway users: an expanded network of toll roads and lanes on high-density expressways, with variable pricing, but using present toll technology; and a road use metering and mileage-charging system that could function on all roads, using technology that automatically measured road use and assessed charges. These could be complementary projects. Expansion of toll roads can begin immediately; however, tolls assessed with conventional technology are limited in application. Road use metering holds the greater promise, but development of technological and institutional capabilities and resolution of privacy and fairness concerns will be prerequisites.

Toll Roads and Toll Lanes

An important opportunity exists today to create an extensive system of tolled limited-access highways and expressway lanes employing existing electronic toll collection technology and variable pricing. The opportunity arises from a convergence of circumstances: the great reduction in the cost and inconvenience of toll collection achieved through new technology; strong interest in several states where tolling is seen as a critical revenue supplement; the willingness of Congress to allow tolling, at least on a trial basis, on Interstate system segments that receive capacity expansions; the valuable experience provided by recent toll implementations; and the interest of private-sector firms seeking opportunities to develop roads. Such a sys-

tem might include networks of the major expressways in each metropolitan area and possibly some heavily traveled intercity connections.

Development of toll roads and toll lanes would have several potential benefits. It would speed construction of some of the most valuable highway projects, improve traffic flow on the tolled facilities (which could include some of the most heavily traveled urban expressways), and allow the public to become aware of the benefits and drawbacks of road pricing and to consider whether more extensive application would be desirable. However, even if tolling were applied to all roads suited to conventional tolling technology, revenue from tolls on limited-access highways and express lanes would remain a small fraction of total road spending. Tolls would likely be beneficial on some roads where toll revenue would be insufficient to pay the full cost of the road. Therefore, arrangements will be needed for funding toll roads with a combination of tolls and other highway user fee revenue.

Soliciting private-sector participation in construction and operation of toll roads may in certain circumstances secure funding for projects that would not otherwise be carried out. However, the toll revenue that would attract the private firm would be available to the government as well. The private sector's most valuable contribution might be in discovering good models for toll road development and operation rather than in funding. Because a private firm in charge of a highway project would face incentives and constraints different from those of a public agency, it could have more success in controlling costs and greater flexibility in setting prices, and it might be able to use the information that pricing would provide more effectively in guiding highway management. There is no guarantee that private firms would outperform public agencies in these tasks. However, in a national effort to expand toll roads, it would make sense to give public–private partnerships a serious trial.

Some prominent proposals for toll road expansion involve parallel toll and free lanes on the same expressway, which would give motorists a choice of services. For example, the 2005 federal surface transportation program reauthorization legislation allows states to convert existing high-occupancy vehicle lanes on federal-aid roads into high-occupancy/toll lanes open to high-occupancy vehicles and toll payers. In addition, the states may build new tolled lanes alongside free lanes on existing expressways through a new federal Express Lanes Demonstration Program. This design may be more acceptable to the public than full conversion of a free road to a toll road, although it will limit the revenue from tolling.

Road Use Metering and Mileage Charging

Creation of a system to assess road users directly for the costs of individual trips offers the best opportunity for increasing the cost-effectiveness of transportation spending and mitigating congestion. The prospects for significant improvement in performance through funding increases or technology advances are limited if reform of road pricing is not car-

ried out. Road use metering and mileage charging appear to be the most promising approach to this reform within a comprehensive fee scheme that will generate revenue to cover the cost of an efficient highway program in a fair and practical manner. These systems use communications and information technology to assess charges automatically according to miles traveled, roads used, and other conditions related to the cost of service.

Conversion to road use metering and mileage charging will require a sustained national effort. Governments must decide on the goals of the effort, authorities for setting fees and controlling revenue, and how best to involve the private sector. The institutional framework and administrative mechanisms to manage such systems must be designed. Among the challenging problems are the following:

- Gaining public acceptance. The public and elected officials will be skeptical of a metering system that could be used to track individuals' movements; therefore, privacy must be guaranteed. Opposition can be anticipated if the new scheme is perceived as unfairly favoring some categories of road users or to be disadvantageous to the poor, and objections can be expected from road users who may be required to pay more or curtail travel. Development must be open and responsive to the concerns of the public about such a fundamental overhaul of highway administration.
- Making the transition from present to new revenue sources. Highway authorities will need to establish procedures for equipping vehicles and roads, discontinuing old fees, and commencing collection of the new fees, with minimum disturbance to revenues or travel, over a period of years. Motor vehicle owners will be required to purchase added equipment with new vehicles or to retrofit their current vehicles. The location of industries and households has been profoundly affected by the current approach to highway financing. A radically new approach may be disruptive (even though the ultimate outcome will be positive) unless it is phased in gradually.
- Setting appropriate prices. Because of inexperience, highway agencies do not now have the competence to set mileage fees that maximize the benefits of the transportation system or to use the information provided by fee revenues to improve the payoffs from capacity expansions. Improper pricing practices could degrade system performance.

The technical design of charging systems can solve some aspects of these problems. For example, design features can help ensure privacy, and the transition will be eased if systems allow users to pay through either the old or the new charging scheme. However, solutions will depend at least as much on the design of institutional arrangements for governance, oversight, monitoring, and evaluation.

If public acceptance is attained, it will most likely come about over time as the result of experience. Expansion of conventional toll roads and applications of

variable pricing and automatic tolling will be important sources of experience. Openness in the development process and demonstrations of effectiveness in early implementation will also be critical in forming opinions.

If mileage charging comes into general use, the state and local authorities responsible for road construction and operation will expect to control the revenue generated by the roads they own and to control pricing decisions that will influence traffic flow, congestion, and land use. However, governments with control of pricing may have opportunities to extract monopoly profits, export congestion to neighboring jurisdictions, or attract development from competing jurisdictions by underpricing. Therefore, safeguards will be needed against practices to gain local advantage at the expense of the general welfare. The problem of inappropriate pricing policies could be lessened by aligning state and local governments' responsibilities for roads with the nature of the traffic. Privatization of the operation of certain roads could also help insulate pricing decisions from narrow considerations.

The general introduction of mileage charging would have profound effects on every aspect of the management of transportation programs. The roles of the federal, state, and local governments would be altered; new criteria would become prominent in the selection of projects; highway managers would have new means of regulating traffic and controlling congestion, pollution, and accidents; and a more nearly optimal balance between transit and highway use and resources in urban areas would be attainable. The opportunity is great, but there are risks that the potential benefits of reform could be dissipated through poor management in the new environment.

RECOMMENDATIONS

1. Maintain and Reinforce the Existing User-Fee Finance System[1]

The nation must continue to rely on the present framework of transportation funding for at least the next decade. Therefore, governments must take every opportunity to reinforce the proven features of the present system, in particular, user fee finance in the highway program. Because of the potential benefits of alternative finance arrangements, delay in developing them probably would be costly. Nevertheless, in the interim it will be necessary to depend on the fuel tax and other existing fees as the primary funding source. The potential gain from reforms within this framework, such as the actions recommended here, may be modest, but a strategy of seeking multiple small improvements in the finance system would nonetheless be worthwhile.

[1] This recommendation parallels a recommendation of the Transportation Research Board's Committee for the Study of Freight Capacity for the Next Century (TRB 2003, 125).

Refining User Fee Rate Schedules

The federal government and the states should make adjustments to user fee rates that would provide incentives for more cost-conscious use of highways by operators of large trucks and other vehicles and allow highway agencies to recover some costs that are not fully accounted for in current fees. At least, the federal government should consider adjustments to the Heavy Vehicle Use Tax to better align fees with the average cost responsibilities for vehicles of different weights and axle configurations. The federal highway cost allocation studies provide an approximate guide to the appropriate adjustments and indicate that certain of the heaviest trucks should pay higher fees unless their operators adopt truck designs that reduce road and bridge wear. The states and the federal government should begin to rely on fees rather than solely on regulations to control vehicle sizes and weights.

Tax Evasion and Exemptions

Congress and the states should consider eliminating fuel tax exemptions that are commonly abused (perhaps replacing them with other aid to their beneficiaries) and requiring that fuel purchasers entitled to lower rates pay the highway rate and apply for a refund.

Too little is known about the magnitude and methods of evasion of federal and state fuel taxes and other highway user fees. However, evidence indicates that it is a significant problem and that better enforcement could increase revenue. A common form of evasion scheme takes advantage of tax exemptions or differences in the tax rates on fuel used for highways and substitutable fuels used for nonhighway purposes. The 2005 federal surface transportation program reauthorization legislation tightened controls on assessment and collection of fuel taxes. The effects of this legislation should be monitored and further action considered if compliance problems persist.

Providing for Advanced-Technology Vehicles in the User Fee Structure

Operators of alternative-fuel or new-technology vehicles should contribute to the upkeep of highways on a basis similar to that of other users. As new kinds of vehicles that do not directly consume gasoline or diesel fuel come into use (for example, hydrogen fuel cell–powered or battery-powered electric vehicles), the present system of fuel taxes and other user fees will be incapable of ensuring that operators of all vehicles pay appropriate shares of the cost of transportation facilities. Adopting mileage charging as the basic user fee would allow equal treatment of all road users regardless of the kinds of vehicles they operated. Other forms of fees (for example, taxes on new fuels that come into use or vehicle registration fees) could accomplish this objective if mileage charging does not become available.

Incentives and other policies to promote conservation or reduce pollutant emissions could be made more cost-effective, and at the same time impacts on transportation program revenues would be lessened, if they were broadly targeted. A tax levied on all fuel consumers (or all polluters) will attain a specified reduction in fuel consumption (or pollution) at lower cost than an efficiency standard or a tax targeting only transportation. Such a tax gives producers and consumers flexibility to reduce consumption (or emissions) in ways that have the least cost to them. An incentive that subsidizes road use by forgiving payment of highway user fees can unnecessarily increase the cost of meeting the conservation or emissions goal by encouraging inefficient use of roads. From the standpoint of transportation finance, promoting energy conservation with a broad-based energy tax rather than a motor fuel tax would have an added advantage—it would segregate revenue of the energy tax from revenue of fuel taxes that were intended as user fees and devoted to covering transportation agency expenditures.

Defining Federal, State, and Local Government Responsibilities

It was not within the scope of the committee's study to develop a complete definition of appropriate federal, state, and local responsibilities in surface transportation. However, federal budget constraints and demands of the states for autonomy may create an environment in the next decade in which level or reduced federal funding is likely, and development of a new system for direct charging for road use would be likely to lead to a reassessment of federal responsibilities. Regardless of the overall scope of the federal surface transportation program in the future, the federal government should retain certain core responsibilities, including the following:

- Providing aid to ensure that the states do not underinvest in routes of major national significance for commerce, travel, and public safety and security. For example, a state may be unwilling to invest in such a route if it cannot collect sufficient user fee revenue from out-of-state vehicle operators to pay for the cost of serving them because travelers buy fuel outside the state.
- Standards setting, in cooperation with states and local governments, to gain efficiencies in construction and operation and to ensure uniformity of highway features needed to allow efficient nationwide passenger and freight traffic (for example, compatibility of road design with vehicles).
- Environmental regulation and enforcement.
- Research and development, since all highway agencies share interest in innovation, especially in the development of improved forms of charging.

These core federal responsibilities ought to be funded by user fees, as the federal-aid highway program is now.

Many states probably could improve the performance of their road programs by periodic review and updating of program responsibilities and jurisdictional control of roads according to analogous criteria. If road use metering and charging come into use, the appropriate spheres of federal, state, and local government responsibility for transportation programs will be altered. State and local governments would be able to raise revenue from all users of their roads and would expect to control revenue and pricing. The need for a federal-aid program would be diminished. However, the core responsibilities listed above would remain. In particular, standards setting and research leadership would be vital federal functions in the program to develop the new transportation funding mechanism. A new federal task, oversight to ensure that governments did not abuse their monopoly pricing powers, might prove necessary. The future revenue source for federal activities would not necessarily have to take the form of a mileage charge. The federal government could continue to rely on excise taxes (at reduced rates) to fund the reduced scope of its activities. States and local governments would be left with primary control of the use and rates of mileage fees.

2. Expand Use of Tolls and Test Road Use Metering

The Federal Role in Promoting Toll Road Development

Good models for toll road development can only emerge from the experience of states. Therefore, the federal government should adopt a strategy of encouraging states to experiment with arrangements for tolling and private-sector participation in road development. To this end, Congress should liberalize the restrictions in the federal highway program that now prevent states from using aid to build toll roads and instituting tolls on roads built with federal aid. In general, states should be allowed to impose tolls on existing roads that were built with federal aid, and they should be allowed flexibility in the design of toll systems.

A common objection to imposing tolls on existing roads is that tolling would be unfair to road users who have already paid for the roads through fuel taxes and other fees. However, existing roads require continuous funding for maintenance and periodic reconstruction. Moreover, congestion fees can greatly improve the efficiency with which capacity is used. Funding an expansion of capacity on a heavily traveled route with revenues generated by that route that are in excess of operating costs is a fair and reasonable means of accelerating improvements that directly benefit payers.

Federal tax policy ought to be neutral with respect to whether a toll road is publicly or privately operated. Use of tax-exempt bond finance in a road project is in effect a subsidy from the federal general fund to the highway program and so violates the user-pays principle. However, it is unlikely that the tax treatment of municipal bonds will be reformed to improve the highway financing system. Therefore, removal of biases in tax law that favor government finance and

operation of toll roads probably is necessary to encourage experiments with private-sector participation in transportation projects. The provision in the 2005 federal surface transportation aid legislation allowing issuance of $15 billion in private activity bonds for highways is a significant measure in this regard. It was noted in Conclusion 5 above that the most important reason for seeking private-sector participation may be the value of bringing the private sector's perspective and expertise to the problems of developing and managing toll roads. If tax-exempt bond finance is the incentive used to attract private involvement, the public subsidy this entails must be worth the improved results that increased private participation in the projects brings about. The subsidy will be substantial if the new private activity bond authority is fully utilized. Congress should monitor the results of the private activity bond provision carefully and then judge whether this trade-off has been in the public interest. It should also assess whether tax-exempt bonds are the most cost-effective form of incentive for private participation. Finally, federal action to reduce the duration, cost, and risks entailed in the project development process, including regulatory reviews, would stimulate private-sector participation.

Road Use Metering

The states and the federal government should explore the potential of road use metering and mileage charging. Creation of a structure to support individual states that decide to conduct trials or pilot implementations may be the most practical initial arrangement. However, a program with national focus will be required, with federal leadership and funding aid for research and testing.

The first steps have already been taken toward developing the capability to meter road use and collect mileage charges. In the United States, detailed proposals for systems have been put forth, and tests of technology are being conducted. In Europe, mileage-charging systems for commercial trucks on motorways are in operation. This experience provides a basis for planning the next stages of development.

Technical Trials Additional technical trials will be the first requirement. The objectives should be to evaluate the reliability, flexibility, cost, security, and enforceability of alternative designs and to gain information about institutional requirements for administering such systems, user acceptance, and costs. Pilot studies will be needed that simulate the important aspects of systems as realistically as possible, including setting rates, billing and collecting fees, enforcement, and coping with malfunctions.

A second necessary research track will be studies with the goal of providing guidance to highway agencies on the proper application and management of road use metering and charging systems. The starting point for this research should be evaluations of the growing number of road pricing systems now in operation.

Finally, planning studies will be needed to lay out possible routes to widespread application of road use metering and pricing. The studies should address the responsibilities and relationships of federal, state, and local governments as well as the relationship of government to private-sector participants.

Staged Implementation After technically practical systems have been demonstrated, several paths exist for continuing with implementation in stages, to allow highway agencies and the traveling public to learn about new road charging systems and decide whether to proceed further.

An individual state or city that wished to proceed with mileage charging would face enormous difficulties because of the high fixed costs of building the first implementations, the complications created by interstate traffic, and the probable eventual need for national coordination of standards and policies. Therefore, once technically proven designs for road use metering and mileage charging are available, the federal government should support one or more implementations that would be on a large scale and fully functional but limited in scope with respect to the region, roads, or vehicles involved. Fee collections can also be used to offset some of the start-up costs.

A limited implementation of road use metering and mileage charging could take one of the following forms:

- A system with participation of large trucks only (possibly starting with metering on Interstates in one region),
- A system applying to all vehicles on the network of expressways in a region (a state, a group of states, or a metropolitan area), or
- A system for all vehicles and roads in one or a small number of states.

These pilot implementations would still be defined as experiments. The motivations would be to limit initial implementation to a simpler task than metering and charging all vehicle travel on all roads and to conduct evaluations that would increase the likelihood that further stages would be accepted and successful. The German Toll Collect system is a precedent for such a staged approach. That system was designed to be applicable to all vehicles on all roads, but implementation was begun with trucks on motorways.

A pilot implementation involving one or a small number of states would be similar to state pilot programs created in past federal transportation legislation (e.g., for congestion pricing and state infrastructure banks). However, the participating states would require federal technical coordination (to ensure eventual nationwide compatibility) and financial aid. Unit costs of onboard equipment and infrastructure for small initial implementations would be high, and a federal subsidy of these costs would be justified to gain the national benefits of large-scale pilot

implementations. For the same reason, the federal government should share the cost of evaluations.

Because planning and development are in only the earliest phase, it is not possible to predict which of such limited implementations would prove to be practical or worthwhile, considering the costs and potential benefits from evaluation and from the experience that would be gained. However, some intermediate steps between purely technical trials and full-scale, fully functional implementations must be planned. A staged implementation seems necessary because initially no state or local transportation agency will have expertise in managing the new funding arrangement, setting prices, or deciding on the disposition of revenues. The pilot implementations would be controlled settings in which to learn best management practices so that jurisdictions would have guidance available when the charging facility became generally available. In addition, the willingness of certain states to take the lead in testing road use metering and the experience of Toll Collect in Germany suggest that pilot implementations may be an effective step toward gaining acceptance of road use metering. As pilots were under way, components of the metering system could be introduced nationwide. For example, new vehicles could be equipped with the necessary devices and the system used to collect tolls on existing toll roads.

Procedures for Trials and Pilot Implementations The following procedural rules should be followed in trials and pilots:

- Evaluation is integral to the design of all trials and pilots and must be provided for in schedules and budgets. Specific objectives and evaluation criteria, hypotheses to be tested, evaluation techniques, and data collection procedures must be defined at the outset.
- Designs and pilot implementations should respect the principle that each state and local jurisdiction should control the application of charges on the roads it owns and operates and the use of revenues generated by its roads. Roads within the boundaries of a city or county may be owned by the city, the county, the state government, or an independent authority. Therefore, systems will eventually be required that have the technical capability to set rates and record revenues for individual roads.
- Pilot implementations should employ only technically proven system designs. It would be a setback for the concept if the first full implementations were hindered by failures that could have been corrected in technical trials.
- Payers of mileage taxes in the pilots should receive refunds of fuel taxes and other user fees they have paid in a way that is visible to them.

Trials and pilot implementations should test whether metering would be applied to all roads or only to certain components of a road system. For example, on the one hand, excluding local streets in residential areas or uncongested rural secondary roads could have advantages from the standpoint of costs, practicality, or public acceptance. Such roads could continue to be funded through traditional mechanisms, probably with little loss of the efficiency benefits of road pricing. On the other hand, excluding some road classes might add to complexity and cost and so would not be worth the effort. Also, pilot implementations should test measures to accelerate the transition from existing user fees to mileage charges by the eligible vehicles, for example, through subsidized retrofit of onboard equipment or other incentives.

3. Provide Stable, Broad-Based Tax Support for Transit

Reforms to highway finance arrangements will give rise to needs for reviewing and adjusting the relationship of highway and transit funding. The following are guidelines that should be considered:

- Transit systems at present require stable and broad-based tax support (for example, dedicated revenues derived from general income, sales, or property taxes). Developing such support will be necessary in order to expand transit services. Among the options available now (which include funding transit out of general revenue, increasing the transit share of highway user fee revenues, and increasing transit fares), such tax funding is preferable because of its practicality and reliability and the importance of minimizing adverse side effects.
- The present rate of transfers of highway revenues to transit does not seem to be large enough to affect highway programs seriously, and highway users benefit where transit has alleviated highway congestion. However, greatly increasing transfers to fund expanded transit services would risk the loss of travel benefits through declining highway performance. Such losses would affect bus transit riders as well as private passenger and freight vehicles and could be greater than the transit benefits gained. Highway benefits would be lost if highway user charges were set too high or if worthwhile highway improvements were not funded. This risk imposes a limit on the potential of existing highway user fees as a transit funding source.
- Federal and state transportation aid ought to serve primarily to relieve local governments of the burden of serving nonlocal needs rather than subsidize local services. Applying this rule would lead to some reallocation of external aid among American cities; cities would be compensated in proportion to

the services they provided to interregional traffic and nonresident users of local facilities.

- If road use metering eventually is instituted on all roads in metropolitan areas, with charges that vary with traffic conditions and are set so that highway travel is no longer subsidized, funding a greater share of transit spending with fare box revenue will be possible. Transit would increase ridership and be able to charge higher fares because peak-period riders would have to pay high mileage charges if they shifted to automobile travel and because reduced traffic congestion would improve transit service quality.

4. Evaluate the Impact of Finance Arrangements on Transportation System Performance

Transportation agencies must develop new capabilities for research, evaluation, and public communication to manage finance reform over the next few decades in a way that improves transportation system performance. Lack of information hinders comparative evaluation of present finance arrangements and alternatives. There is little systematic information on how the existing structure of charges, subsidies, and grant programs affects the decisions of road users and transportation agencies, even though these interactions undoubtedly exert strong influence on the benefits and costs of transportation programs. Agencies almost never evaluate completed projects after they have been in operation to determine what the actual returns on their investments have been.

If tolls and mileage charges become important sources of highway funding, transportation agencies will be faced with new kinds of decisions and new information requirements. For example, transportation program budgets will be influenced by the revenue impacts of decisions about project selection and operating practices. At the same time, the response of traffic to fees and the revenues generated by the fees will provide information never before available about the value the public places on individual highway facilities. Transportation agencies will need to develop the analytic capabilities required to exploit this new information and manage their programs in the new financial environment.

To fulfill these requirements, an organized program of research, evaluation, planning, and public communication will be necessary. The institutional structure of this program will require careful design. Among the considerations are the following:

- Because the states have the primary responsibility for transportation funding and changes in funding probably will entail realignment of federal and state roles, the structure must be a genuinely cooperative federal–state effort.
- The structure must guarantee that competent, objective, and independent scientific evaluations of alternatives are carried out.

- The activity must earn public confidence through open processes and effective communication.

Congress has recently created the National Surface Transportation Policy and Revenue Study Commission. Parts of its charge are to study alternative revenue sources to fund the surface transportation system for the next 30 years and to develop a transition strategy to move to new funding mechanisms. Although the commission can begin evaluations, development of fundamentally new finance arrangements and the supporting evaluations would extend well beyond its term. Defining the appropriate organization of the development program and its scope of work would be an appropriate topic for the commission's consideration.

REFERENCE

Abbreviation

TRB Transportation Research Board

TRB. 2003. *Special Report 271: Freight Capacity for the 21st Century.* National Academies, Washington, D.C.

APPENDIX A

Highway Benefits Estimates

This appendix describes the evaluations that are summarized in the section in Chapter 3 entitled Highway System Performance. The descriptions note uncertainties that arise from simplifying assumptions and data limitations in the studies.

U.S. DEPARTMENT OF TRANSPORTATION HIGHWAY *CONDITIONS AND PERFORMANCE* STUDIES

Neither the federal government nor the states conduct systematic retrospective evaluations of the costs and benefits of projects. The U.S. Department of Transportation (USDOT) does, however, prepare biennial reports to Congress (the *Conditions and Performance* studies) that estimate the benefits of alternative future rates of capital spending for highways.

The estimates are derived from a model (the Highway Economic Requirements System) that uses data on traffic, geometry, and state of repair of each of a sample of road segments reported to the Federal Highway Administration by the states. A set of cost factors allows the model to project infrastructure and user costs for each segment for specified assumptions about future road improvements and traffic growth. Given a forecast of traffic and a budget, the model selects the most cost-effective highway improvements.

The USDOT studies present historical trends for physical measures of highway condition (pavement smoothness, bridge structural condition, and numbers of bridges with obsolete designs) and performance (congestion, average speed, and accident risks). The 2002 study concluded that physical conditions of highways were unchanged or slightly improved during the 1990s. For example, the fraction of all vehicle miles on main roads that were on pavements meeting an engineering standard for minimum acceptable ride quality was nearly constant (at 90 percent) over the decade (USDOT n.d., ES-4). Performance was found to have deterio-

rated: the fraction of all travel on freeways and principal arterial streets that is in congested conditions increased from 34 to 40 percent between 1987 and 2000 in urban areas with populations exceeding 3 million and from 18 to 22 percent in urban areas with populations under 500,000.

The 2002 study projected the effects of alternative rates of highway capital expenditure on highway user costs (travel time, vehicle operating costs, and accident costs) over the period 2001–2020. In the projections, the future level of highway travel depends on the cost of travel. The projections indicated that, if all highway capital projects nationwide with a benefit–cost ratio greater than 1 were carried out, annual capital spending would average $107 billion (in 2000 dollars). To maintain overall conditions and performance at 2000 levels, annual capital spending of $76 billion would be required, 17 percent above actual capital spending of $65 billion in 2000. The latter estimate suggests that the present spending level plus normal growth in spending may be nearly sufficient to maintain performance to 2020. The estimated discrepancy between actual and maximum justified spending in the 2002 report was somewhat less than in the previous report (USDOT 2000). The reduction presumably reflects the increased rate of highway spending in the late 1990s.

The 2002 report did not present estimates of returns on investment. However, the previous report estimated that if all projects with benefit–cost ratio greater than 1 were carried out over the 20-year period 1998–2017, the average benefit–cost ratio would be 3.7 (USDOT 2000). The projections showed that, at all spending levels analyzed up to the maximum economically justified level, congestion will be little improved. The fraction of urban travel that is under congested conditions increases by 2020, although annual hours lost to congestion per driver fall slightly at the higher spending levels (USDOT n.d., 9-8).

The *Conditions and Performance* studies also compare the mix of kinds of projects that USDOT estimates would be most beneficial with the mix that highway agencies have been carrying out in recent years. The 1999 study concluded that benefits would be increased if agencies shifted spending from capacity expansion to system preservation. The 2002 report, attributing the change in part to large investments in preservation starting in the mid-1990s, concluded the opposite—that the mix should now be shifted to expansion (USDOT n.d., iii).

The USDOT model used to produce these projections has been critiqued by a Transportation Research Board committee (TRB 2003, 56–58, 127) and by the General Accounting Office (GAO 2000), which concluded that the studies have value for the purposes intended. The model also was relied upon by the Congressional Budget Office to analyze highway spending effectiveness (CBO 1988, 4–20). CBO prioritized categories of highway investment in terms of national average rates of return (in the 1980s) as follows: projects to maintain current conditions, 30 to 40 percent annual rate of return; new construction in urban areas, 10 to 20 percent; projects to fix roads not meeting minimum engineering

design standards, 3 to 7 percent; new construction in rural areas, "low" except for bridge replacements to carry large trucks.

The USDOT model has important limitations. It does not support comparisons of highway expansions with demand management alternatives. It does not incorporate a network model; consequently, the estimate of benefits from expansion of a highway link does not change if a decision is made to expand a substitute or complementary link simultaneously. It cannot evaluate trade-offs between capital expenditure and maintenance. Environmental costs are not taken into account. The model takes as given certain design standards and regulatory requirements that strongly affect project costs. Data quality is a concern, and projections are sensitive to values of elasticity parameters in the model, which are not known with a high degree of certainty.

Finally, the model's projections of justified spending levels assume that projects are performed in order of their rates of return, with the highest-payoff projects given highest priority until the budget is exhausted or the minimum acceptable rate of return is reached. In practice, state and local highway agencies do not rank projects exclusively according to economic returns, and there may be regional disparities in rates of return that result from the state allocation formulas in the federal-aid program. However, priorities in state and local capital programs certainly are influenced by factors (including volume of traffic, severity of congestion, degree of deterioration of pavement and structures, and project costs) that are related to rate of return.

PRODUCTIVITY BENEFITS OF HIGHWAY INVESTMENTS

Several economic studies in recent years have produced estimates of the return on highway infrastructure investment by using statistical methods to examine how infrastructure affects production costs or contributes to output, for the national economy or for industry groups at the national or regional level (reviewed by Shirley and Winston 2004, 399; ICF et al. 2001; Aaron 1990). This section describes the results of the four studies that are highlighted in Chapter 4.

Keeler and Ying (1988)

This study estimated a cost function for the intercity trucking industry (that is, the relationship of total annual production costs in the trucking industry to industry output, the prices of inputs, and external factors that influence productivity, including highway infrastructure). The study was based on aggregate industry data from the Interstate Commerce Commission for each of nine regions for 1950 to 1973. Highway capital stock in each region was represented by an index similar to that described in Chapter 2 and shown in Figure 2-12. Only state-maintained roads (or federal-aid roads for some calculations) were included in the capital stock

measure, as an approximation of the network of main freight-carrying intercity roads. The authors used data only through 1973 because their data showed highway capital stock growing so slowly in the following decade that the later observations added nothing to their ability to estimate the effect of changes in the highway stock on trucking costs.

The results showed savings reaching $6 billion to $9 billion annually by 1973 (in 1973 dollars) for the total of U.S. intercity truck traffic that would have occurred without the expansion of the highway system. The savings depends on the value assumed for the elasticity of truck traffic volume with respect to trucking costs. The estimated annualized capital cost of the intercity highway network during the period was $18 billion per year based on a 12 percent interest rate and a 25-year life of new stock and $11 billion per year based on a 6 percent interest rate. Therefore, these truck savings justified one-third to one-half of the total capital cost of the intercity highway system at the higher interest rate and 55 to 80 percent of capital costs at the lower interest rate. Highway maintenance and operation expenditures were $9.6 billion in 1973 (FHWA 1997, Table HF-210), so the estimated trucking cost savings equaled between one-quarter and one-half of total capital costs plus operating expenses.

These estimates cover only part of the total benefit of highways. They exclude the benefit derived from the additional truck traffic stimulated by highway system expansion during the study period as well as benefits derived from business traffic other than freight trucks and from personal travel. Freight truck traffic was 5 percent of all vehicle miles of travel in 1973.

Year-by-year estimates showed that by the early 1970s, the marginal benefits of increases in the highway capital stock were becoming small. This is not an implausible result since by the early 1970s a basic network of Interstate highways had been completed. The authors noted that this is the same period during which expansion of the system also slowed and speculated that the system may have been responding to considerations of economic efficiency.

Shirley and Winston (2004)

A model of the inventory holding costs in U.S. industry was developed. Transportation system improvements are expected to reduce inventory holding costs by increasing the speed and reliability with which firms can replenish inventory. Firms are willing to bear the capital and operating costs of holding inventories of production inputs in order to avoid the costs of lost sales and production disruption if they run out. Also, if transportation is expensive, firms will tend to order replacements in large quantities to gain bulk shipment economies. If transportation becomes cheaper, quicker, and more reliable, the cost of running out of stock is reduced because inventory can be replenished quickly, replacement orders will be smaller and more frequent, and inventory size and cost will decline.

The study estimated the reduction in inventory costs caused by expansion of the highway system in the period 1973–1996. The authors estimated the parameters of an econometric model relating a plant's inventory to variables representing the firm's expected demand for its product, highway infrastructure, and the interest rate and other variables representing inventory holding and stockout costs. Annual establishment-level inventory data were from a Census Bureau survey. Highway infrastructure was represented by capital stock measures for the nation and for the state in which each establishment was located. The results showed that at all times during the study period, additional investment in the highway capital stock caused plants to reduce their inventories. Finally, inventory savings were scaled to an estimate of total economywide logistics cost savings by multiplying by a constant factor.

The authors estimated that the annual rate of return on net investment in the highway capital stock from these savings was 18 percent during the 1970s (i.e., an additional $1 of net highway capital stock reduced costs by $0.18), 5 percent during the 1980s, and 1 percent during the 1990s.

The authors speculated that the decline in the rate of return over time was the result of finance- and management-related factors, including the growth in project earmarking in the federal-aid program, misdirection of spending for expansions, and lack of congestion pricing. However, they had little evidence that these shortcomings were more severe in recent years than in the 1970s. Both the trucking cost study and the inventory cost study found steep declines in rates of return over the periods studied, but the former found a low rate of return in the 1970s and the latter found a relatively high return during that period.

Fernald (1999)

This study took a more aggregate approach than those described above. It examined the link between highway capital expansion and industry productivity growth. The study used data on production and inputs for 29 industry groups (covering the entire U.S. private economy except agriculture and mining) for the period 1953–1989. It estimated the relationship of growth in total factor productivity in each sector to growth in the national highway system and to the stock of motor vehicles that each industry owns, as a share of its total capital stock. The premise of this model was that if expansion of the highway system contributes to productivity growth, industries that make more intensive use of motor vehicles will benefit more from highway expansion. An estimate of the rate of return earned by highway investment was derived from the observed "excess" productivity growth in the motor vehicle–intensive industries.

The results indicated that for the period as a whole, road expansion contributed strongly to productivity growth and that the return on additional road investment greatly exceeded the normal private-sector rate of return. The estimates

implied rates of return exceeding 100 percent, at least in the first part of the study period—that is, the addition of $1 worth of roads reduced business costs by more than $1 per year. Separate estimates for the pre- and post-1973 periods indicated that after 1973 the rate of return was somewhat lower and that the difference between it and the normal rate of return was not statistically significant. The author emphasized a qualitative interpretation of the results: "roads appear strongly productive before 1973. After 1973, the productivity of roads is statistically significantly smaller, and we cannot reject that roads have a normal (or even zero) return" (Fernald 1999, 632). The uncertainty in the estimate of the post-1973 rate of return is very large, because there is little variability in road growth after that date (in fact, the stock of roads nearly stopped growing in the period 1973–1989). These findings—large overall returns but an apparent sharp decline in the early 1970s—closely parallel those of Keeler and Ying.

Nadiri and Mamuneas (1998)

The final study, sponsored by the Federal Highway Administration, estimated the contribution of highway capital to productivity in 35 industries and in the entire U.S. economy for the period 1950–1991. Demand and cost functions were estimated for each industry. Highway capital stock and the stock of other publicly provided infrastructure were explanatory variables in the cost functions. The marginal benefits of highway capital for each industry were calculated from the parameters of the demand and cost equations. The study found annual rates of return on highway capital of 54 percent for 1960–1969, 27 percent for 1970–1979, and 16 percent for 1980–1991 (Nadiri and Mamuneas 1998, Table 12). That is, in the 1980–1991 period, an additional $1 of highway capital stock produced annual cost savings in private business equal to 16 percent of the total social cost of providing the additional capital. (The social cost of an added $1 in capital spending may be a little more than $1 because of economic distortions in the private sector caused by taxation.) The authors observed that by the end of the period, rates of return on highway and private-sector capital appear to have converged.

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Abbreviations

CBO	Congressional Budget Office
FHWA	Federal Highway Administration
GAO	General Accounting Office
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

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APPENDIX B

Automotive Technology Projections

This appendix explains the assumptions and methods of the fuel economy projections summarized in Table 4-2 and presents results of two additional studies (SMP 2004; NRC 2004).

ANNUAL ENERGY OUTLOOK

Table 4-2 and Figure 4-4 show the Department of Energy's (DOE's) 2005 *Annual Energy Outlook* (AEO) projections of light-duty vehicle fuel economy to 2025 in the reference case and the "high technology" case (EIA 2005a). Figure 4-4 also shows the reference case fuel economy projections from the 2006 *Annual Energy Outlook Early Release* (EIA 2005b). DOE explains its 2005 vehicle technology projections as follows (EIA 2005a, 82, 83, 86):

> Fuel efficiency is projected to improve more rapidly from 2003 to 2025 [in the reference case] than it did during the 1990s. . . . No changes are assumed in currently promulgated fuel efficiency standards for cars and light trucks. Low fuel prices and higher personal incomes are expected to increase the demand for larger, more powerful vehicles, with average horsepower for new cars projected to be 26 percent above the 2003 average in 2025. . . . Advanced technologies and materials are expected to provide increased performance and size while improving new vehicle fuel economy. . . . Advanced technology vehicles . . . are expected to reach 3.8 million vehicle sales per year and make up 19.1 percent of total light duty vehicle sales in 2025. Alcohol flexible-fueled vehicles are expected to continue to lead advanced technology vehicle sales. . . . Hybrid electric vehicles . . . are expected to sell well, increasing to 1.1 million vehicles [sold] in 2025. . . . About 80 percent of advanced technology sales are as a result of Federal and State mandates for fuel economy standards, emissions programs, or other energy regulations. . . . The high technology case assumes lower costs and higher efficiencies for new transportation technologies.

DOE also acknowledges numerous sources of uncertainty related to fuel price, consumer preferences, and regulation (EIA 2005a, 54, 55):

> Recent introductions of more efficient crossover vehicles . . . , increasing consumer interest in environmentally friendly vehicles, the possibility of sustained high fuel prices, and increasing consumer demand for improvements in vehicle performance and luxury all will influence the future of light-duty vehicle sales and fuel economy. In addition, carbon emission regulations for light-duty vehicles that have been issued in eight U.S. States and Canada would require improvements in vehicle fuel economy starting in 2009 that go beyond those required by current U.S. CAFE standards. (*AEO2005* does not include the impact of these carbon emission regulations, because their future is uncertain. . . .) NHTSA is also considering modification of the light truck CAFE standards. . . . In summary, considerable uncertainty surrounds the future of light-duty fuel economy.

As Figure 4-4 shows, light-duty fleet on-road fuel economy improves only slightly in the AEO 2005 cases, reaching 21.0 mpg in 2025 (compared with 20.2 in 2003) in the reference case and 22.1 mpg in the high technology case. New light-duty vehicle miles per gallon is projected to rise from 25.0 in 2003 to 26.6 in the reference case to 28.2 in the high technology case in 2025, according to the Environmental Protection Agency (EPA) fuel-economy definition. (These cannot be directly compared with the fleet projections because on-road fuel economy is about 15 percent poorer than EPA-definition fuel economy.)

Gasoline consumption is 4 percent less, and total energy consumption in transportation 5 percent less, in the high technology case in 2025 than in the reference case. In the AEO 2005 "high B" oil price case (not shown in Figure 4-4), the price of gasoline in 2025 is 27 percent higher than in the reference case, light-duty fleet fuel economy reaches 21.7 mpg in 2025, and gasoline consumption is 7 percent less in 2025 than in the reference case. In summary, DOE projected that no likely developments in automotive technology, regulation, or world energy prices would have more than a modest effect on fuel economy or highway fuel consumption by 2025.

In the AEO 2006 *Early Release* reference case projections, which assume future world oil prices similar to those of the AEO 2005 high B oil price case, in 2025 light-duty fleet fuel economy reaches 22.0 mpg and new light-duty vehicle (EPA) mpg is 28.8.

NATIONAL RESEARCH COUNCIL'S CORPORATE AVERAGE FUEL ECONOMY STANDARDS STUDY

This 2002 report of a National Research Council (NRC) committee examined the historical effects of the federal corporate average fuel economy (CAFE) standards and the prospects for future fuel economy improvements characterized as "cost-

efficient," for various classes of vehicles. The report defines cost-efficient technology as "combinations of existing and emerging technologies that would result in fuel economy improvements sufficient to cover the purchase price increases they would require, holding constant the size, weight, and performance characteristics of the vehicle(s)" (NRC 2002, 64). The technologies considered are those that could be in production by 2015. The cost-efficient increases in miles per gallon range from 12 percent for subcompact automobiles to 42 percent for large SUVs. The hypothetical vehicles with improved fuel economy were designed by adding increments of technology improvements in order of cost-effectiveness until no further cost-effective improvements were available. Consequently, according to the NRC estimates, the total savings to the vehicle owner would exceed the purchase price of the new technology. The study does not consider the market response to the availability of such vehicles; that is, it does not consider the extent to which consumers would buy them if they were offered as an option or whether consumers would take advantage of cost savings by buying larger or better-performing vehicles.

The study estimates cost-effective fuel economy improvements under two alternative assumptions about the rate of return on expenditures for fuel savings that consumers would require: that consumers would discount fuel cost savings at a 12 percent discount rate over the entire 14-year average life of a vehicle, or that they would require a 3-year payback period. The fuel economy projections from the study that are described in Chapter 4 are those that assume the 12 percent discount rate over 14 years.

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM STUDY OF HIGHWAY TRUST FUND IMPACTS

The National Cooperative Highway Research Program (NCHRP) study was specifically concerned with the effects of possible vehicle technology and regulatory developments on Federal Highway Trust Fund revenues to 2020, under the assumption that tax rates are unchanged. The fleet mpg projections shown in Table 4-2 are for a scenario in which the government adopts new CAFE standards paralleling the new-vehicle mpg values by size that the NRC 2002 study estimated to be cost-efficient. The NCHRP study also independently reviewed prospects for six technologies for light-duty vehicle power:

- Hybrid internal combustion–electric vehicles. These are on the market now; the Honda Insight and Toyota Prius have EPA-rated fuel efficiencies of 75 and 57 mpg, respectively.
- Purely electric vehicles with rechargeable batteries.
- Fuel cell–powered vehicles running on either hydrogen or gasoline.

- Hydrogen-fueled internal combustion engine–powered vehicles.
- Internal combustion engine vehicles fueled by compressed or liquefied natural gas.
- Diesel engine power for light-duty vehicles. The report notes that diesel is popular in Europe, with 40 percent of the light-duty vehicle market, mainly because it has a 40 percent efficiency advantage (in gpm) over gasoline. Diesel is also of interest because technology is available (the Fischer–Tropsch process) to manufacture diesel fuel from natural gas or coal.

The judgment of the authors was that, of these technologies, only hybrid vehicles have a high probability of attaining a large enough market share by 2020 to have an appreciable effect on trust fund revenues, while a substantial shift to diesel is a low- to medium-probability event. Adoption of any of the other technologies in this period was judged to be a low- or very-low-probability event (Cambridge Systematics 2004, Table 6). The authors cite in support the 15 percent market share projection for hybrid vehicles by 2020 in DOE's *Annual Energy Outlook.* That forecast is driven in part by DOE's expectation of continued future tightening of fuel economy or emissions standards by the federal and state governments.

FUTURE U.S. HIGHWAY ENERGY USE

The DOE *Future U.S. Highway Energy Use* study constructs six strategies for the directed evolution of the automotive travel system to 2050 that are judged to be feasible or conceivable and compares their outcomes with a base case forecast that assumes the absence of new government interventions. The strategies involve adoption of new-vehicle technologies, changes in travel habits, and development of new fuel sources. The outcomes of the strategies are judged in terms of their impacts on carbon emissions and oil imports and are estimated to be capable of producing large reductions in both measures (Birky et al. 2001, 17–26). The base case forecast appears to be generally consistent with the DOE *Annual Energy Outlook.*

CALIFORNIA CO_2 EMISSIONS STANDARDS PROPOSAL

According to California law enacted in 2002 (Assembly Bill 1493), by 2005 the state is to "develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles." The law specifies that the regulations are to be "economical to the owner or operator of a vehicle." The regulations affect model year 2009 and later vehicles. The law stipulates that regulations are not to require imposition of additional fees on vehicles, fuels, or miles traveled; banning of any type of vehicle; reduction in weight; limits

on speed; or limits on miles traveled. The state's proposal on emissions standards to implement the law is relevant as a current technical analysis of practical fuel economy improvements and as an indicator of the form that future regulations affecting fuel economy may take (CARB 2004).

In the proposal, the regulations take the form of an addition to the state's existing new-vehicle emissions standards. Each motor vehicle manufacturer would be required to meet standards for the average emissions per mile of carbon dioxide (or other pollutants equivalent in greenhouse warming effect) for its new vehicles sold in California, beginning in 2009 and with more stringent standards applied annually through 2014. The 2014 standard for cars and smaller light trucks would represent a 34 percent average reduction from 2002 emissions (and up to 39 percent for some manufacturers); the standard for larger light-duty pickups would represent a 30 percent reduction compared with 2002 emissions (CARB 2004, iii, 95). The regulation would also include a credit for vehicles burning alternative fuels to allow for differences in net greenhouse gas (GHG) emissions in production of alternative and conventional fuels.

As the basis of its proposal, the California Air Resources Board (CARB) conducted a review to determine fuel economy technologies that would be available to meet the proposed implementation schedule and would satisfy the legislative requirement that the standards be economical to vehicle operators. The promising technologies identified include engine and drivetrain improvements that are now available or in development and expected to be available. They include turbocharging combined with engine downsizing, automated manual transmissions, and engine design changes to allow optimized valve timing (CARB 2004, ii, 54–57). The emissions standards are derived from the estimates of fuel economy improvements that these technologies could yield but leave the selection of technologies up to manufacturers. The standards are estimated to increase the average purchase prices of new vehicles by amounts ranging from $500 for a sedan to $1,000 for a large pickup or SUV but to reduce life-cycle costs to owners in all vehicle classes. The payback period would be 3 to 5 years for typical drivers (CARB 2004, 150–152).

The technology review does not project that compliance with the 2014 standard will entail a substantial market share for hybrid electric vehicles (HEVs), presumably because this technology appeared less cost-effective or practical as a near-term measure than the engine and drivetrain improvements that are the basis of the proposed emissions standard. HEV is identified as a long-term technology with large-scale implementation appropriate after 2014 (perhaps in response to a future tightening of emissions standards, although the report does not explicitly state this possibility). Advanced HEV systems are credited with the potential to reduce CO_2 emissions (and fuel consumption) by half. Similarly, certain diesel engine designs are identified as promising in the long term (after 2014) (CARB 2004, 54–57).

The standards are projected to reduce fuel-related operating costs (and presumably fuel consumption per mile) by 31 percent for 2014 new cars and smaller light trucks and by 21 to 26 percent for larger light-duty trucks (CARB 2004, 151). GHG emissions from motor vehicle operation (that is, excluding the effect of the regulation on emissions from fuel production) are projected to be reduced by 17 percent in 2020 and 25 percent in 2030 (in terms of equivalent tons of CO_2) compared with projected emissions without the regulations (Figure B-1). The reductions are almost entirely in CO_2 emissions. Approximately the same percentage reductions would occur in gallons of motor fuels consumed. The state's evaluation of the proposed regulation considered the effect of increased purchase price on new-vehicle sales and total vehicle registrations and of lower operating cost on vehicle miles of travel. It concluded that both effects would be small: essentially no effect on fleet size and less than a 1 percent effect on vehicle miles (CARB 2004, 152–161).

MOBILITY 2030

This report, the product of the World Business Council for Sustainable Development, an international business group, presents projections of technology for the

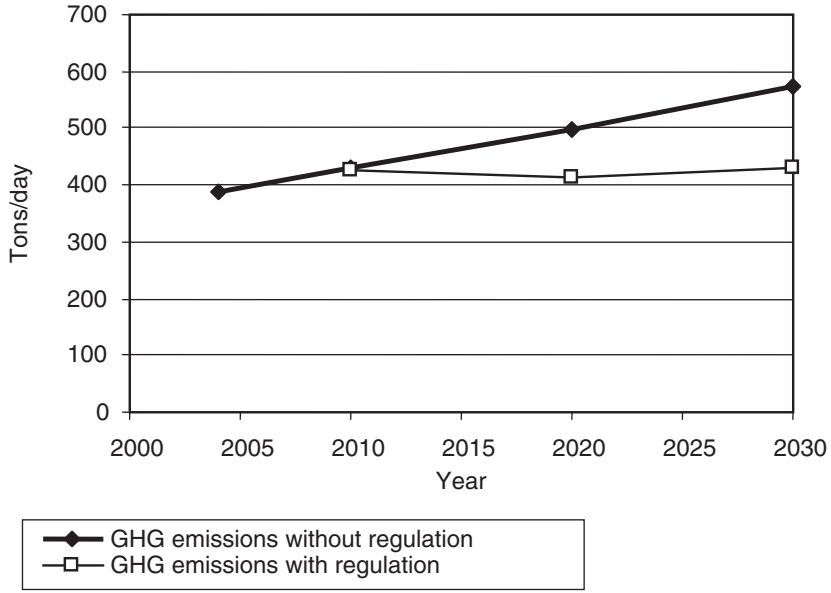

FIGURE B-1 California proposed CO_2 emissions regulations: projected effect on GHG emissions from motor vehicle operation. (Source: CARB 2004.)

world motor vehicle fleet, but not for the United States alone. The purpose was "to obtain a better sense of the potential impact of various technologies and fuels in reducing transport-related GHG emissions." The report explains that "our exercise did not examine the technical or economic feasibility of any of the actions being simulated" (SMP 2004, 113). However, the study did consider feasibility and cost and reviewed estimates of the cost and retail price impact of motor vehicle technologies.

One projection scenario is driven by the objective of reducing motor vehicle CO_2 emissions by half by 2050 from the level projected to occur in a reference case in which historical trends continue (SMP 2004, 115–117). In the projection, by 2030, half of worldwide light-duty vehicle sales are hybrid vehicles and 45 percent use diesel fuel (these could be hybrids or conventional diesel vehicles). Fuel cell–powered light-duty vehicle sales start in 2020 and are 50 percent of sales by 2050.

NRC HYDROGEN FUELS STUDY

In a DOE-sponsored study, an NRC committee examined the prospects for a conversion to hydrogen as a major fuel in the U.S. economy, and it recommended research and development priorities. The study includes a projection of the feasible rate of conversion to hydrogen fuel cells for motor vehicle propulsion, characterized as a "plausible, but optimistic vision" (NRC 2004, 65), which suggests the possibility of much earlier conversion to new propulsion technologies than the other projections reviewed in this chapter. In the projection, conventional internal combustion engines make up 27 percent of new-vehicle sales and 50 percent of vehicle miles of travel by 2025; hybrid and fuel cell vehicles are 75 percent of sales and 50 percent of vehicle miles of travel. By 2030, hybrid and fuel cell vehicles are 90 percent of sales and 75 percent of vehicle miles of travel. Highway gasoline consumption grows only 17 percent from 2000 to 2025 (compared with 63 percent growth in DOE's *Annual Energy Outlook* 2003 reference case projection) and declines after 2015. It falls below 2000 consumption after 2030.

It is not clear what probability the committee placed on this projection. The committee explains that "this vision is not a prediction. . . . However, it is offered to allow some specificity in the analysis of the possible implications for the U.S. energy system of a transition to hydrogen" (NRC 2004, 64). The report also describes the projection as an "upper-bound market penetration case for fuel-cell vehicles" (NRC 2004, 117) and explains it depends on the assumption that by 2015 to 2020 technology progresses to the point that fuel cell vehicles "have the same functionality, reliability, and cost associated with their gasoline fueled competitors." The committee did not conduct its own analysis of vehicle costs. In contrast, the CARB and NRC CAFE standards studies, for example, included

component-by-component projections of costs and development schedules. The report does not discuss the driving forces that would be necessary to bring about the projected conversion, but presumably the committee postulated the carrying out of a large-scale and successful industry research and development program, with strong government financial or regulatory incentives for research and sales.

One of the study's major findings is that "these impacts [of hydrogen-fueled light-duty vehicles] are likely to be minor for the next 25 years" (NRC 2004). If the projection is taken as an upper bound, it indicates that the highest plausible market share of fuel cell vehicles in 2030 will be 20 percent of vehicle miles of travel. However, the projection suggests that rapid growth after 2030 is conceivable.

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Abbreviations

CARB	California Air Resources Board
EIA	Energy Information Administration
NRC	National Research Council
SMP	Sustainable Mobility Project

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APPENDIX C

Review and Synthesis of Road Use Metering and Charging Systems*

Executive Summary

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Many public officials and transportation analysts are concerned with what they perceive to be the waning buying power of the motor fuels tax. Because the tax is levied on a per-gallon basis, revenues do not rise and fall with fluctuations in inflation or vehicle fuel economy. Given the partisan political climate in which it has grown increasingly contentious to propose increased taxes, many are pessimistic about the prospects for significant increases in state or federal motor fuels tax levies in the years to come. Indeed, the occasional increases in state and federal motor fuels taxes in recent decades have fallen far short of keeping pace with the combined effects of inflation and gains in fuel economy over the same period. On the other hand, annual vehicle miles traveled in the United States have continued to skyrocket for a wide variety of reasons, including population growth, increased affluence and vehicle ownership, greater participation of women in the workforce, and increasingly decentralized metropolitan land use patterns, among others. These increases in vehicle travel have exacerbated both congestion of and wear and tear on roads, leading to calls for increased spending on the construction of new roads as well as on the maintenance of existing roads. The result has been a

* This paper was commissioned by the committee in support of its study. The contents are the responsibility of the authors and the views expressed do not necessarily correspond to those of the committee. The complete paper may be found at www.trb.org/publications/news/university/SRFuelTaxRoadMeterPaper.pdf.

widening gap in many parts of the country between highway spending needs and available revenues. In the absence of significant fuels tax increases in the coming years this gap is likely to widen further, a trend that may accelerate in coming years with the gradual introduction of alternative-fuel vehicles that pay less, or even no, motor fuels taxes.

In response to these challenges, the Transportation Research Board convened a special Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance. One of the many charges to the committee was to investigate the potential for a system of distance-based user fees [using recently developed electronic tolling technologies such as on-board computers, Global Positioning Systems (GPS), digital jurisdiction and road network maps, and wireless communications] to eventually replace fuels taxes. To inform their deliberations, the committee commissioned the authors of this report to perform an extensive review of innovative electronic tolling applications around the world. This review included projects already in operation as well as those that have been proposed or are in the advanced stages of planning; each was evaluated in terms of policy, technology, and political acceptance issues. This report summarizes the results of this research.

SCOPE AND METHODOLOGY

In selecting case studies to review for this research, we focused on applications that involve networkwide road use metering and tolling, as we judged these to be the most relevant to the concept of distance-based user fees. As a secondary focus, we reviewed facility congestion toll projects and cordon toll projects that might be relevant from a political or technical perspective. We did not examine standard (time-invariant) toll projects that incorporate simple electronic tolling devices (such as in-vehicle transponders), given that such projects would likely offer little technical or political guidance in the design of a comprehensive distance-based user fee system.

Within the context of the study, the goal was to address three principal questions. First, where in the world have such innovative systems been proposed, planned, or developed? Second, how have these projects and proposals been structured in terms of technical design, institutional issues, and political considerations? Third, what is the current status of the projects and proposals, and what factors have aided or impeded their implementation?

In terms of methodology, possible case studies were identified and investigated for inclusion. The scan was based on a review of the literature, a comprehensive search for documents on the World Wide Web, and several phone interviews with experts in the field. The next step was to compile a set of detailed case studies for

those projects deemed politically and technically relevant to the question at hand. Each detailed case study considered the following topics:

- Stated and implicit objectives of the system;
- Techniques of metering road use and collecting fees;
- Pricing policies;
- Governance;
- History and political setting;
- Experience with public acceptance or rejection;
- Financial structure; and
- Summary of any evaluations that have been conducted for the project or views of those involved with the project, or both.

Once the case studies were compiled, the final step was to compare and contrast the different projects in order to provide perspective on the prospects for implementing a comprehensive distance-based user fee system, including the advantages and the likely obstacles to such an approach. The synthetic analysis was divided into five main sections:

- Policy and pricing issues,
- Technical issues,
- Institutional governance issues,
- Implementation issues, and
- Public and political acceptance issues.

SUMMARY OF CASE STUDIES

Given the motivations for the study discussed above, the review focused on five distinct types of pricing applications. These included single-facility congestion tolls, cordon (or area) congestion tolls, weight-distance truck tolls, distance-based user fee proposals, and distance-based price-variabilization (e.g., insurance-by-the-mile) studies. In total, 88 different pricing schemes—either operational or in the advanced stages of research or planning—around the world were identified that fell into one of these categories. Of these, 20 were selected for detailed review—specifically, those that were considered to be technically and politically relevant to the question of distance-based user fees.

Ultimately, none of the facility or cordon congestion tolls identified in the initial survey (such as the central London program) were selected for the set of

detailed case studies, because none of these uses a technology platform that potentially could be extended to implement a distance-based user fee program. On the other hand, many of these applications are already operational, and they certainly entail innovative pricing schemes in transportation finance. For this reason, there are occasional references made to relevant findings from such projects within the policy and political acceptance sections of the synthetic review. Most of these observations are drawn from the following projects, all of which have been operational for at least two years:

- Facility congestion tolls: I-15 HOT lanes, SR-91 HOT lanes, Katy HOT lanes; and
- Cordon congestion tolls: London, Singapore, Norway (Trondheim, Oslo).

For weight-distance truck tolls, distance-based user fee proposals, and distance-based price variabilization studies, most of the projects identified were included as detailed case studies. Although many of the truck tolls are already operational, most projects within the other two categories are still in the planning or demonstration trial phases. The specific set of case studies reviewed includes the following:

Weight-distance truck tolls (international)

- Australian "Austroads" truck monitoring proposal (planning phase),
- Austrian "GO" truck toll (operational 2004),
- Bristol truck toll/cordon toll (trial completed),
- German "Toll Collect" truck toll (operational 2005),
- Swiss "HVF" truck toll (operational 2001), and
- U.K. truck toll (planning phase).

Distance-based user fee proposals (United States)

- CWARUM, a conceptual proposal by Daniel Malick;
- University of Iowa study (trial pending);
- Oregon Department of Transportation study (trial pending); and
- Puget Sound Regional Council study (trial ongoing).

Distance-based user fee proposals (international)

- ARMAS Pan European Tolling Project (trial ongoing),
- Copenhagen demonstration project (trial completed),

- Gothenburg demonstration project (trial completed),
- Helsinki modeling study (study completed),
- Netherlands "Mobimiles" proposal (canceled 2002), and
- Newcastle on Tyne research project (study completed).

Distance-based cost variabilization studies (United States)

- Atlanta variable insurance study (study ongoing),
- Minnesota "PAYD" study (study ongoing), and
- Progressive Insurance study (study ongoing).

POLICY AND PRICING OBJECTIVES

Collectively, the pricing projects that were examined incorporate a wide range of policy objectives, though the specific goals tend to vary depending on the type of application. Table 1 provides a list of the most common stated and implicit objectives and indicates the most relevant policy goals for each category of projects. Note that an entry of "primary" indicates that the objective is one of the driving motivations behind most or all of the projects within a given category, while an entry of "secondary" indicates that the goal was identified explicitly in only a minority of the projects reviewed. Note also that under the category of distance-based road user fees, several of the objectives (such as reducing demand for travel by increasing its marginal cost or encouraging the adoption of lower emission vehicles

TABLE 1 Policy Objective Summary

Policy/Pricing Objective	Weight–Distance Truck Tolls	Distance-Based User Fees	Cost Variabilization
Preserve revenue		Primary	Secondary
Charge equitable costs	Primary	Primary	Primary
Charge external users	Primary	Secondary	
Enforcement	Secondary		
Efficient regulation	Secondary		
Reduce road wear	Secondary		
Improve safety	Secondary	Secondary	
Optimize capacity		Primary (Intl)	Secondary
Reduce demand	Secondary	Primary (Intl)	Primary
Improve environment	Secondary	Primary (Intl)	

NOTE: Intl = international.

through appropriate fee offsets) are considered by the project developers to be of primary importance for the international projects but only of secondary importance for those in the United States.

In addition to policy objectives, the projects studied also exhibit considerable variation in terms of the travel characteristics to be metered and priced. At the highest level, these characteristics can be divided into four separate categories. First, each of the projects includes, at a minimum, a measure of *total distance traveled* (which is not surprising, given the selection criteria through which the projects were chosen). Second, a number of the projects also consider the *time of travel,* either for the application of congestion toll surcharges during hours of peak travel or for the enforcement of operating regulations (in the case of trucks only). Third, most of the projects also incorporate some determination of the *location of travel.* In the simplest case, this might be limited to geographic area, for the basic identification of separate charging zones (e.g., determining whether the user is traveling in California or Oregon). At finer levels of detail, the pricing schemes seek to distinguish between different road classes (e.g., to vary truck tolls based on highway versus nonhighway use), between specific links in the road network (e.g., to layer on additional fees for traveling on pre-existing toll facilities), or even between different lanes on a given link [e.g., for the hypothetical implementation of virtual high-occupancy toll (HOT) lanes]. Fourth, some of the projects also include the *characteristics of the vehicle* in determining fee levels. The most common examples of this fee structure include weight and axle configuration (for trucks) and vehicle emissions categories (to provide incentive for purchasing cleaner and more efficient vehicles).

The final major consideration in the area of policy and pricing pertained to the distribution of revenues. For most of the projects evaluated, the majority of the funds are dedicated to road maintenance and expansion. In several cases, however, a considerable portion of the revenue has been set aside to subsidize alternate modes such as transit or rail freight.

TECHNOLOGY APPROACHES

The in-vehicle equipment used within the various projects studied incorporates a wide array of technologies. In all cases, the equipment includes an on-board unit (OBU), essentially a computer that serves to integrate the other components, store data, and calculate charges owed. In addition, each configuration relies on one or more technologies to determine vehicle location or distance traveled, or both. Here, the range of possible options includes dedicated short-range communications (DSRC) devices, GPS receivers, geographic information systems (GIS) loaded with digital jurisdiction or road network maps (or both), odometer feeds, and dead-reckoning systems. Finally, each design also must include a means of transferring billing data to the collection agency. The three primary technology

choices for this component include DSRC, global system for mobile (GSM) communications (satellite-based cellular), and removable smart cards.

Collectively, the set of technologies incorporated within the OBU must facilitate four important functions: (1) measuring usage to determine fees owed; (2) communicating usage and billing information; (3) maintaining user privacy for passenger vehicles (this is less relevant for commercial trucks); and (4) preventing toll evasion.

To meter road usage, several different technology configurations have been proposed, studied, or employed:

- **DSRC communicating with readers along the roadway:** This is typically applicable for weight-distance truck tolls that apply only on highway links, where it is relatively easy and cost-effective to mount transponders on overhead gantries. Given the impracticality of installing DSRC transponders throughout the entire road system, this option has not been proposed for full, networkwide pricing schemes.
- **Odometer with DSRC on/off toggle:** In this option, DSRC transponders are mounted at the entrances to a jurisdiction (e.g., where a highway crosses from one country to another). When a vehicle enters a charging jurisdiction, the DSRC signal sets the on-board unit status to "on." From that point, the odometer is used to measure distance traveled within the jurisdiction. When the vehicle exits once again, another signal from the DSRC transponder sets the on-board unit back into the "off" status.
- **Odometer with GPS on/off toggle:** This is similar to the DSRC toggle option. Instead of relying on transponders mounted at border crossings, however, the on-board unit relies upon a GPS signal (combined with a digital jurisdiction boundary map) to determine whether the vehicle is within a particular charging zone or not.
- **GPS standalone:** In this case, the GPS is used to determine both position and distance traveled. Unfortunately, the GPS signal may at times be lost temporarily (especially in urban or mountainous regions), making this approach impractical for full-scale implementation.
- **GPS with odometer backup:** To account for periods when the GPS signal is not available, the odometer can be used as a backup measure for distance traveled until the signal is available once again. Regrettably, the odometer is not capable of providing location information, making it difficult to determine whether the vehicle has remained within the same charging zone.
- **GPS with odometer and dead-reckoning backup:** To help determine location (and thus applicable charging zone) while a GPS signal is down, the unit also can be equipped with dead-reckoning equipment in addition to the odometer feed.

As noted, there are three primary approaches for communicating usage and billing data:

- **GSM:** This is the most costly option but also the most flexible. Because it allows for real-time communication from anywhere within the network, it also can be used to facilitate value-added capabilities such as way-finding, fleet management, and emergency distress signals.
- **DSRC:** Although this technology is robust, well tested, and inexpensive, it can be used only for communicating at fixed points throughout the network (specifically, where transponders have been mounted, such as on overhead gantries or at fueling stations). Though adequate for many applications, it does not provide the opportunity for value-added services, as does GSM.
- **Smart cards:** These are essentially small data-carrying devices that can be removed from the OBU and inserted into card readers (for example, at gas stations or on a home computer) to send billing data to the collections authority. With this option, the end user has full control in determining when the data are transferred; on the other hand, smart cards do not facilitate a fully automated billing process because some manual intervention is required.

Most of the systems studied devoted considerable attention to protecting user privacy. The primary concern has been to ensure that governments do not have unrestricted access to detailed travel records for individual drivers (this has been more of a concern for private passenger vehicles than for commercial trucking operations). To achieve this aim, two primary approaches have been proposed:

- **On-board aggregation:** The first approach, which is more prevalent for full-scale operational proposals, is to aggregate all travel information and determine the total bill owed on the on-board unit itself. With this strategy, the government never sees any of the details of the travel history for any individual, just the total amount of the bill.
- **Third-party privacy agreements:** In this second approach, the on-board unit communicates detailed travel information to a third-party billing agent, which in turn aggregates the data and submits only the total bill to the government. As with phone companies, the third party is legally obligated to keep these data private except in the case of a court subpoena. Consumers appear to be more wary of this approach, however, and to date it has been employed only within truck tolling projects or in research trial projects.

To help prevent toll evasion, two potentially complementary strategies have been discussed:

- **Tamper-proof OBUs:** Here the goal is to ensure that users are unable to turn off or temporarily disable the on-board units during periods of travel. Some of the alternatives suggested include tamper-proof seals on the OBU itself, disabling the engine if the OBU is not functional, and checking the OBU against the odometer to ensure that the mileage records are consistent.
- **External verification:** Under this strategy, DSRC transponders are mounted at various locations throughout the network, sending signals to passing cars to ensure that the on-board equipment is activated and functioning properly.

INSTITUTIONAL ISSUES

In reviewing the case studies, two major institutional issues of importance were identified. First, is the system designed to handle a single jurisdiction or multiple jurisdictions? Second, what are the respective public and private roles for oversight, operations, and the provision of technology?

About two-thirds of the case studies identified, including all of the weight-distance truck tolls and several of the distance-based user fee proposals, were designed, at least initially, to be implemented for single jurisdictions. Over the longer term, however, there appears to be a high probability that many single-jurisdiction programs will evolve to include multiple jurisdictions. For example, the distance-based user fee proposal in Oregon is currently structured to measure mileage within that state alone. However, if California or Washington elected to pursue a similar pricing scheme at some point in the future, then they might very well seek to leverage the same technology that Oregon already has developed. Fortunately, from a technical standpoint, it is relatively trivial to structure the on-board unit to record data and calculate fees for single or multiple jurisdictions. On the other hand, once peer-level jurisdictions (e.g., multiple states or countries) join together in a road pricing project, it may be necessary to develop new institutional capabilities for collecting the revenues and distributing the appropriate amounts to the different parties involved.

In terms of public and private roles, oversight responsibilities for most of the programs reviewed (with the exception of some of the distance-based insurance pricing studies) fell primarily within the public realm. For operations, in contrast, there was a roughly even split between public and private responsibility; most of the multiple-jurisdiction programs relied on private contractors for routine administration duties, whereas a larger percentage of the single-jurisdiction programs opted for public administration. Finally, all of the cases studies tapped the private sector for the provision of the on-board equipment and supporting technology. In most of the cases, especially those for which user participation is mandatory, single firms (or consortia) were contracted to be the sole providers of the technology.

However, for a few of the intended applications in which participation would be optional, the proposals have been structured to allow multiple vendors to compete for users on the basis of price as well as additional value-added services (such as navigational aids or fleet management).

IMPLEMENTATION ISSUES

Two principal implementation issues were identified: whether user participation is required or optional and whether the rollout is immediate or phased in over time. For most of the user fee programs, participation is mandatory, particularly for "internal" users (i.e., those who live or work within the charging jurisdiction). In contrast, participation is usually optional for travel monitoring (as opposed to pricing) programs (as in the case of the Australian "Austroads" program), variabilized insurance pricing, or "external" users (e.g., foreign truckers operating within a country with weight-distance truck tolls).

The mandatory participation programs must determine in advance whether the equipment rollout will be staged simultaneously or phased in over time (for optional programs, in contrast, the rollout is phased in by definition). Most of the weight-distance truck tolls, for example, have opted to require internal users to install the on-board equipment at the onset of the charging program. In contrast, most of the distance-based user fees that involve private passenger vehicles have envisioned some strategy for phasing in the equipment over time (for instance, with the purchase of new vehicles). It is important to note that for programs in which the rollout occurs gradually, it is necessary to develop a strategy for operating multiple charging schemes in parallel throughout the transition phase (for example, newer cars with on-board equipment installed might pay mileage-based fees while older cars continued to pay the fuels tax).

POLITICAL AND PUBLIC ACCEPTANCE ISSUES

In reviewing the various factors that influence the prospects for political and public acceptance of new pricing schemes, two issues stood out most prominently: equity concerns and privacy concerns. With respect to equity, proposals for new pricing mechanisms invariably are subjected to higher levels of scrutiny than existing transportation finance programs. For example, equity concerns rarely are raised over the increasingly common dedication of sales taxes, despite the fact that such taxes are recognized widely to be regressive with respect to both income and highway system use. On the other hand, equity concerns almost always loom large for electronic tolling proposals, especially congestion tolls. This likely is due to the fact that they usually represent a "new" form of pricing (as opposed to a distance fee, which essentially would replace the existing gas tax), and because they place the

correlation between ability to pay and benefits received into especially sharp relief. For the various projects that incorporated some form of congestion tolling, we observed the following:

- Equity concerns have contributed to the demise of many congestion pricing proposals.
- Actual equity outcomes can vary considerably from one project to the next, depending on user demographics and program design.
- Despite frequent equity concerns, congestion tolling is on the rise.
- Many congestion tolling programs have mitigated equity concerns through the dedication of revenues (for instance, to subsidize transit).

In contrast to congestion toll proposals, equity issues are not usually raised with regard to weight-distance truck tolls, distance-based user fees, or variabilized insurance.

As with the question of equity, the level of concern over privacy issues depends on the nature of the pricing program. Generally speaking, privacy issues are less relevant for weight-distance truck tolls, given their commercial nature, or for congestion tolls, which don't typically track vehicles continuously through time and space. In contrast, privacy can be perceived as a significant issue for general-purpose distance-based user fees, as such programs involve private citizens and use equipment that, at least theoretically, allows for extensive vehicle tracking and monitoring. From the review of the various case studies, the following observations were made:

- Privacy concerns do not appear to pose legal issues.
- Public concern over privacy issues may not in fact be particularly widespread, given the prevalence of credit cards and cell phones, two other devices that provide a wealth of detailed information about individual behavior.
- Where privacy is a significant concern, it has been addressed at the technical level (through on-board aggregation of data) or at the programmatic level (with third-party billing and confidentiality agreements).

In addition to equity and privacy concerns, several other factors that may play a strong role in the level of public and political acceptance of new pricing schemes were identified. These include the following:

- **Severity of the problem and effectiveness of the solution:** New pricing schemes appear more likely to be accepted if the problem is considered severe, if other solution strategies have already failed, and if the proposed pricing scheme is deemed likely (or has been demonstrated elsewhere) to be effective.

- **Integration with complementary policies:** New road pricing schemes that integrate complementary policies—such as the improvement of transit options—appear to have increased the likelihood of implementation.
- **Size and scope of the project:** Projects of larger size and scope—with more users affected and more aspects of road use priced—appear to face more difficult prospects for political success given that they may engender resistance from a larger and more diverse array of stakeholders.
- **Dedication of revenues:** From the cases reviewed, it appears that the public is more willing to accept pricing programs when revenues are dedicated to transportation improvement projects rather than allocated into general funds.
- **Manner in which stakeholders are compensated:** In most of the programs investigated, one or more stakeholder groups will be affected adversely by the new pricing scheme. To counter or mitigate potential political resistance, many of the successful programs developed some way to compensate such groups. For instance, the weight-distance user fee in Switzerland raised the overall level of user fees for truckers (so as to encourage mode shift to rail) but also allowed for higher weight limits on the highway network in order to facilitate greater operating efficiencies among trucking firms.
- **Degree of choice offered, or precluded, by the program:** Findings show that programs seeking to expand the choices available to travelers (such as HOT lanes or cordon congestion tolls integrated with improved transit facilities) have tended to enjoy greater prospects for success than programs that limit or preclude the level of choice (such as all-lanes congestion tolls or cordon toll proposals in cities not well served by transit).
- **Transparency and user-friendliness of the system:** Developing fare structures that are readily understood and payment collection technologies that are seamless from the user's perspective appears, from the case studies reviewed, to be critical to establishing a high level of public and political acceptance.
- **Effectiveness of the enforcement strategy:** In many of the case studies reviewed, the effectiveness of the enforcement strategy was cited as a major issue for public acceptance; more specifically, users appear more likely to resent a new pricing scheme if they perceive that others may be able to cheat the system and evade payment.

CLOSING OBSERVATIONS

Of the many types of issues involved in our case studies of electronic tolling, three appear to exert the greatest influence on the prospects for the success of distance-based user fees: (1) the embedded policy objectives, (2) the technical strategy, and

(3) the factors that influence political and public acceptance. Institutional and technical implementation issues are also important, of course, but these details appear less likely to affect the technical and political feasibility of electronically based pricing programs.

With respect to policy objectives, distance-based user fees can be designed to accomplish a wide array of goals, depending on the characteristics of travel that are metered or priced.

- **Revenue enhancement or preservation:** A distance-based user fee can readily serve as a replacement to the standard fuels tax, and its effectiveness would not be compromised by increasing vehicle fuel efficiency (or even the introduction of alternative-fuel vehicles) in the years ahead. Given the substantial price tags associated with transitioning to these types of systems, however, it is not clear whether this approach would be superior to simply increasing current fuels taxes over the short term (though, as noted above, such increases face increasingly difficult political odds). Conversely, a distance-based user fee may very well prove necessary within several decades with the anticipated widespread introduction of alternative-fuel vehicles.
- **Optimizing road capacity, managing demand:** By using the technology base for a distance-based user fee system, it is relatively straightforward (from a technical standpoint) to layer on congestion tolls that would apply along specific corridors or within crowded urban areas during periods of peak travel for the purposes of optimizing road capacity or managing demand and encouraging mode shift.
- **Reducing road damage, improving the environment:** It is also possible to build in offsets to the standard distance fee based on axle weight or emissions class in order to encourage users to purchase and operate vehicles that impose less damage on roadways or the environment.

On the technology front, the most significant finding is that it is technically feasible and increasingly cost-effective to develop a system for distance-based user fees. In terms of specific technologies and general technical strategies:

- **GPS:** GPS by itself is not sufficiently reliable to measure location and distance traveled, given that the signal often may go down during travel between tall buildings or in mountainous areas. For this reason, such systems need to be supplemented by an odometer feed (as a backup for distance traveled) and possibly a dead-reckoning system (as a backup for location). The question of accuracy may be another important issue. For applications where it is necessary only to determine whether or not a vehicle is within a particular jurisdiction (e.g., a country or a state), GPS and existing digital maps provide a sufficient level of accuracy. However, for applications in which

it is necessary to distinguish between different road links on the network, differential GPS signal correction and highly accurate (and expensive-to-create) road network maps will be required.

- **Communications strategies:** DSRC, GSM, and smart cards all represent viable communications options; the appropriate choice depends on price (GSM is the most expensive by far) as well as desired functionality (GSM is also the most flexible).
- **Enforcement strategies:** To prevent toll evasion, tamper-proof OBU strategies appear to offer the most promise, though external roadside checks using DSRC transponders may add a useful level of redundancy.
- **Simple system designs:** Generally speaking, and not surprisingly, applications that have relied on relatively simple technical configurations (leveraging, as often as possible, off-the-shelf technologies) have experienced the greatest implementation and budgetary success. Increasingly, electronic tolling programs are starting with simple systems that are upgraded to a greater level of complexity later.
- **Conservative implementation schedules:** For many projects, the process of development, integration, and planning has taken far longer than originally anticipated. This underscores the importance of providing sufficient flexibility within the implementation timelines to account for unanticipated technical difficulties.
- **Backup plans:** As a corollary to the above, program designers (in most, though not all, cases studied) have designed system redundancy and backup plans for levying user fees should technical difficulties lead to delays in the implementation of the electronic tolling system.

Finally, in terms of the factors that influence the prospects for political and public acceptance of distance-based user fees, the following issues are the most relevant:

- **Equity concerns:** In general, equity is raised as a concern more for congestion tolls than for distance-based charging schemes. In distance-based user fee proposals not involving congestion surcharges, equity concerns have been far less of a political barrier. But since one of the ultimate goals of many distance-based electronic tolling programs is to develop systems that eventually include both distance fees and congestion tolls, equity concerns may be raised subsequently for already established tolling programs.
- **Privacy concerns:** In contrast to equity, concerns over privacy are most common in distance-based user fee programs, given that the combination of technologies employed within on-board equipment can be used to record and disseminate detailed information on the travel patterns of individual

drivers. Fortunately, it is possible to ensure the privacy of user data, both at the technical and institutional levels. On the other hand, many press accounts continue to highlight concerns over privacy, despite the fact that this issue has been addressed satisfactorily in many of the cases studied. For this reason, efforts to implement distance-based charging schemes often include coordinated public education campaigns to address and diffuse popular and political objections to tolling proposals on privacy grounds.

- **Other factors influencing public and political acceptance:** Along with equity and privacy, a number of other issues appear to be important with respect to building public and political support for new pricing programs such as distance-based user fees. Most notably, these include the severity of the problem to be addressed and the inadequacy of other solution strategies, the degree of integration with other related policies (such as the provision of improved transit service), the degree to which "losers" under the new pricing regime can be compensated in some manner, perceptions over the adequacy of the proposed enforcement scheme, and the expansion or contraction of travel options created by the program.
- **Keys to building public and political support:** In addition to the programmatic factors that can influence the level of public and political acceptance, experience from the various cases studied indicates that there are a variety of strategies that pricing program proponents have pursued to enhance the prospects for political success. These include establishing the technical details of the program early on (so as to build confidence in the feasibility of the project), engaging in sophisticated marketing efforts (including focus groups, targeted messaging, and coordinated framing of the debate), reaching out to key stakeholder groups early in the process, cultivating political champions, actively courting the media, and providing positive testimonials from other successful projects of a similar nature.

Study Committee Biographical Information

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Martin Wachs is Director of the Transportation, Space and Technology Program at the RAND Corporation in Santa Monica, California. From 1996 to 2005 he was Director of the Institute of Transportation Studies and Professor of City and Regional Planning and of Civil and Environmental Engineering at the University of California, Berkeley. His research is in transportation planning and policy, including public transit systems and evaluation of alternative transportation projects. Recently, his writings have dealt with transportation finance and with the relationships among transportation, air quality, and land use. Professor Wachs is a Past Chair of the TRB Executive Committee. From 1971 to 1996 he was on the faculty of the University of California, Los Angeles. He holds master's and doctorate degrees in transportation planning from Northwestern University and a bachelor's degree in civil engineering from the City University of New York.

The Fuel Tax and Alternatives for Transportation Funding

Highway programs derive most of their funding from fuel taxes and user fees paid by vehicle operators, including registration fees and tolls. Most of the revenues from these fees go to highways, with a share to transit. This study assesses the prospects for continuing to generate revenue from these fees and identifies alternative financing arrangements.

The study committee concludes that the finance system has contributed to the success of the highway program by delivering a positive return on the national investment in highways; moreover, user fees can remain the primary funding source for another decade or more. Transitioning to a fee structure that charges vehicle operators directly for the use of roads, however, could benefit the public by reducing congestion and by targeting investment to the most valuable projects. The committee recommends that governments expand tolling on expressways and explore techniques for charging each vehicle according to miles traveled on all roads.

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Transit Cooperative Research Program, Synthesis of Transit Practice 56, ISBN 0-309-07018-X,
74 pages, 8.5 x 11 paperback, 2004, $16.00

Transportation Finance, Economics, and Economic Development 2004
Transportation Research Record: Journal of the Transportation Research Board, No. 1864, ISBN 0-309-09457-7, 159 pages, 8.5 x 11 paperback, 2004, $50.00

The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs

National Academy of Engineering, National Academies Press, ISBN 0-309-09163-2,
240 pages, 8.5 x 11 paperback, 2004, $32.00

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