
# International Perspectives on Road Pricing (2005)

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# International Perspectives on Road Pricing

**Report of the Committee for the International Symposium on Road Pricing**

**November 19–22, 2003**
**Key Biscayne, Florida**

*Sponsored by*
Florida Department of Transportation
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# Preface

In November 2003, approximately 160 people assembled in Key Biscayne, Florida, to participate in the International Symposium on Road Pricing. Fifteen countries were represented, and the exchange of information on policies and approaches adopted throughout the world was one of the symposium's most noteworthy features. The conference also benefited from the breadth of sectors represented; participants and speakers included members of academia and researchers, public officials from all levels of government, consultants, interest group and association representatives, and individuals from financial and legal firms. The conference was a collaborative effort of the Transportation Research Board (TRB), the Florida Department of Transportation, the Organisation for Economic Co-operation and Development (OECD), and the Federal Highway Administration.

The symposium was conducted under the auspices of TRB's parent organization, the National Research Council (NRC). In cooperation with OECD, a specially appointed NRC committee developed the symposium to explore American and international applications of road pricing strategies in various governmental and socioeconomic settings. The participants discussed the rationale and motivations for implementing pricing strategies, the use of pricing revenues, and project outcomes. Drawing on resource papers, presentations, and symposium discussions, the conference committee evaluated the current state of practice, assessed future directions and opportunities, and identified research and information needs.

## Beyond *Curbing Gridlock*

This conference built on the foundation established in *Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion*, a 1994 report developed by TRB in conjunction with NRC's Commission on Behavioral and Social Sciences and Education. That publication included recommendations on the potential role of market pricing principles as a tool for congestion management, guidelines for the assessment of impacts of congestion pricing experiments, and fruitful areas for further research, demonstration, or experimentation.

The program for the Key Biscayne gathering was designed in recognition of the significant extent of experimentation with road pricing since 1994. While *Curbing Gridlock* and meetings leading up to its publication focused largely on the rationale for testing road pricing, the organizers of this conference sought to develop a program that would provide a detailed look at case studies of applications throughout the world and the results of research focused on specific pricing projects. To that end, the conference committee commissioned two resource papers, both of which appear in this document. One of the papers dealt with the evolution of pricing, with special attention to the state of the practice today. The other also focused on the state of the practice, with special attention to pricing initiatives outside the United States.

By the time the conference was over, participants had learned from the speakers, resource papers, and each other about the successes realized to date and the challenges that accompanied specific projects' implementation. To round out the session, the conference committee invited top-level policy makers or advisers from around the globe to point out any continuing concerns and offer their visions for how road pricing will or ought to evolve in the coming decade.

## Acknowledgments

This conference would not have been possible without the financial and institutional support of the Florida Department of Transportation. Special thanks are extended to Lowell Clary, Assistant Secretary of the department, for

his vision and assistance. Thanks also go to Jon Williams of TRB, who played a key role in developing the concept of the symposium, and to Martine Micozzi of OECD for facilitating that organization's involvement in this project.

The committee acknowledges the work of many individuals who contributed to the conference and the development of this report. Claire L. Felbinger, Transportation Policy and Management Specialist, worked with the committee and coordinated with the OECD Working Group for the International Road Pricing Symposium (see box) to plan the conference, under the guidance of the committee and the supervision of Mark Norman, TRB's Director of Technical Activities. Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. The committee also thanks Reginald Gillum, Meetings Coordinator, who coordinated registration and the on-site logistics for the conference, and Mary Kissi, Senior Program Assistant, who provided administrative support throughout the project. Thanks are extended to Miriam Roskin, Roskin Consulting, for her work in assembling and preparing this report under the guidance of the committee.

The presentations, discussions, and summaries of the views expressed by conference speakers, panelists, and participants are intended to provide a record of the conference. The views expressed do not necessarily reflect those of the conference planning committee, TRB, NRC, or the sponsors of the conference.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that assist the institution 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 review of this report: Thomas F. Barry, Post, Buckley, Schuh & Jernigan, Orlando, Florida; Shama Gamkhar, University of Texas at Austin; Jacquelyne D. Grimshaw, Center for Neighborhood Technologies, Chicago, Illinois; H. David Prior, Dellard Sphar, Philadelphia, Pennsylvania; and William Stockton, Texas A&M University System, College Station. Although these reviewers provided many constructive comments and suggestions, they were not asked to endorse the report's findings and conclusions, nor did they see the final draft before its release.

The review of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by NRC, he was responsible for making certain that an independent examination of this 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.

### OECD Working Group for the International Road Pricing Symposium

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# Background and Terminology

In any discussion of road pricing, one of the first challenges is to clarify definitions. The conference committee was charged with organizing a symposium to explore American and international applications of road pricing strategies in various governmental and socioeconomic settings. Although they are often used interchangeably, the phrases "road pricing," "congestion pricing," "value pricing," and "variable pricing" can have different meanings to different users. This document typically uses the phrase "road pricing." Under a road pricing strategy, road users are charged a fee that reflects the cost of their use of the road more fully than do existing fees and taxes, and thus pricing can serve as a public policy tool to help manage demand for a limited resource—road space. Because of its role in managing demand, road pricing is often referred to as "congestion pricing," particularly in cases where the charge rises at peak travel times and falls or is eliminated entirely when demand is low.

As with any other genuine pricing system, road pricing allocates road space to those most willing to pay for it, provides guidance in the revenues collected as to where capacity expansion is needed, and creates one source of money for paying for investment. Pricing a road is thus different from traditional turnpike tolling, which aims merely to produce revenue to recover costs and plays no reallocative function.

While the term "road pricing" generally suffices as a shorthand phrase to indicate the allocation of scarce road space through the use of charges that vary with the level of congestion on a road, other, more specific vocabulary has emerged in the road pricing community as well. The following are some examples:

- *Value pricing*. The term "value pricing" was proposed in place of the term "congestion pricing" by the U.S. Department of Transportation during the development of pricing legislation to convey the benefits ("value") of using pricing to reduce congestion. However, some choose to limit the term's meaning to charging for use of additional road lanes that offer premium service alternatives to unpriced highways.
- *Cordon*. A ring around an area (typically a city center) with a series of charging points at all entries. Both Singapore and London use a cordon approach.
- *Area charging or licensing*. A variant of cordon charging in which the charge is levied to use a vehicle within a defined area, rather than just to enter it.
- *Distance-based charges*. In contrast to cordon or area-based charges within a defined area, distance-based charges represent fees that vary depending on the distance traveled.
- *Managed lanes*. A lane or lanes designed and operated to achieve stated goals by managing access via user group, pricing, or other criteria. A managed lane facility typically provides improved travel conditions to eligible users.
- *High-occupancy/toll (HOT) lanes*. A variant of the high-occupancy vehicle (HOV) carpool lanes commonly used throughout the United States, HOT lanes are managed lanes that provide free (or reduced cost) access for transit and other vehicles carrying the required number of passengers and charge a fee to

other vehicles not meeting occupancy requirements. Emergency vehicles are typically exempt from the fee.

An alternative to HOT lanes that has been mooted but is untried is the concept of FAIR (fast and intertwined regular) lanes. If implemented, FAIR lanes would divide currently free, general-purpose traffic lanes into two sections: fast lanes and regular lanes. Under FAIR lanes, drivers using the regular lanes during peak hours would be compensated with credits that could be used as toll payments on days when they chose to use express lanes. The express lane credits would compensate drivers for giving up their right to use lanes that they "have already paid for" and for any added delays that might result.

- *HOT networks*. This concept expands the idea of HOT lanes to a complete network of premium service lanes offering both congestion relief to motorists and improved transit service. A HOT network would be developed by adding missing HOV lanes and converting the entire operation to electronic variable pricing. Access would be at no charge to "super-HOV" vehicles (vanpools and buses), which would preregister to use the system and carry transponders granting them passage at no charge. All other vehicles would pay a toll intended to maintain high-speed, free-flow traffic at all times. A seamless network of this sort would provide the functional equivalent of an exclusive busway, since pricing would be used to guarantee a predefined amount of capacity for buses and vanpools.

# Committee Findings and Recommendations

Immediately after the symposium's closing session, the conference committee convened to develop its consensus findings and recommendations. Consideration of the content of the conference presentations, discussion, and resource papers led to the committee's identification of a series of key findings, recommended topics for future research, and suggested areas for international cooperation. In addition, the committee drew on the resource papers and presentations made throughout the symposium to identify a number of potential policy initiatives that were frequently cited in the discussions. This summary of the committee's findings and recommendations addresses each of these issues.

## Key Findings

The state of the practice in road pricing has advanced considerably since the publication of *Curbing Gridlock* in 1994, at which time congestion-based pricing schemes were largely a theoretical proposition rather than a practice. More recent contributions were the European Commission's 1998 *White Paper on Fair Payment for Infrastructure Use*, which made a general call for the phased introduction of marginal social cost pricing for infrastructure use, and its 2001 *White Paper on European Transport for 2010*, which specifically called for the gradual replacement of existing transport system taxes with more effective instruments for integrating infrastructure costs and external costs.

Over the past 10 years, many pricing experiments have been implemented in various forms and in several countries. Much of the experience of the past decade has been more successful than anticipated, with fewer adverse impacts and greater public acceptance. This positive experience—which is occurring in the context of increasing financial necessity, diminishing opportunities to add capacity, and advancing technological ability—makes it important for policy makers to continue to enable and learn from further experimentation.

Despite expanded use of road pricing in Asia, Europe, and the United States, the pricing structures used in these parts of the world vary. As noted in the resource papers prepared for the symposium, the best-known road pricing projects in Europe and Asia involve cordon or area pricing, typically with drivers paying a fee to cross a cordon and enter a congested central city area during business hours. Alternatively, in the United States pricing projects have tended to focus on drivers' use of a specific facility, such as a highway, where fees are levied for travel during periods of congestion.

Pricing's transformation from a theoretical construct to a real-world application is underscored by new national policies providing greater official sanction for pricing experiments. These include the European Commission's 1998 call for the phased introduction of marginal social cost pricing for infrastructure use and, in the United States, national legislative proposals to provide state and local officials with broader discretion to use "value pricing" on federally funded roads.

While the efficiency gains produced by road pricing projects are largely undisputed, the impacts of pricing initiatives on equity, fairness, and transparency in decision making remain areas of concern. Assessment of the

relative impacts of pricing arrangements on various groups stratified by income, ethnicity, gender, employment status, residential and job location, and other characteristics continues to be a prime area for research. Development of strategies to mitigate inequitable distributions of costs and benefits also merits attention. For example, policy makers increasingly recognize that "revenue recycling," whereby some or all of the revenues generated through a pricing project are returned to the public at large either as direct credits or as subsidies to public transportation, can help reduce adverse equity impacts.

Many at the symposium believed that revenues from priced facilities should be available first and foremost to pay for the operations and maintenance of the priced facility, retire debt for that facility, and potentially offer a return to investors. After these uses, and in part because of concerns over pricing's equity impacts, many conference participants also suggested that the proper hypothecation (or dedication) of excess revenue is a key ingredient in a pricing project's success. Views differ on how broadly or narrowly to prescribe the eligible uses of revenue and how best to disperse the revenue in the local corridor or area.

Road pricing is still often perceived to be synonymous with traditional turnpike tolling, which leads to the misperception that pricing is principally or exclusively a revenue-generating mechanism. Unless the transportation community or others demonstrate pricing's ability to meet other management objectives, the public and politicians will continue to view pricing simply as a revenue tool. Pricing advocates will find real-world examples to be their strongest tool in countering these misperceptions. The City of London's area pricing program, for example, is achieving greater delay reductions than had been expected. This was the pricing scheme's goal; it was not concerned solely with raising revenue. Consequently, the pricing scheme was a form of demand management rather than revenue enhancement. Moreover, London's plan featured an integrated strategy that included road signal improvements, public transportation improvements, infrastructure repair, and the adoption of new technologies. The tolling examples in the United States do not exhibit this integrated approach and have mixed results concerning demand management.

Cordon pricing such as that used by the City of London may be less attractive in the United States, according to resource paper author Martin Wachs, because of the fear that it will drive more people to outlying suburban centers. "American downtowns," he notes, "can be said to fear road pricing much more than they fear congestion" (see resource paper by Wachs, p. 69 of these proceedings).

As noted by many speakers at the conference and as highlighted in the resource papers, recent experience suggests that citizens' anxiety about planned road pricing projects far exceeds their actual dissatisfaction with pricing once a project is in place. In fact, while resistance to pricing can be a potent barrier to implementation, recent surveys demonstrate unexpectedly favorable attitudes toward the implemented project. For example, one recent survey indicated that both users and nonusers of priced lanes typically perceive travel time savings to be even greater than those actually realized. Other surveys indicate that highway users are becoming increasingly skeptical that added capacity can reduce congestion in a sustainable way and are increasingly convinced that efforts to manage demand could be more beneficial.

With some of the more difficult implementation questions already tackled, concerns that may previously have been treated as lower research priorities can no longer be ignored. These areas include methods of enforcement; strategies for ensuring privacy; goods movement and pricing; the externalities of pricing; public participation; and a much more sophisticated understanding of the distributional impacts of various pricing structures in light of individuals' income levels, racial or ethnic status, gender, residential location, modal choices, and other relevant groupings.

The impacts of pricing on location, land use patterns, and urban form are still relatively poorly understood, not least because of the difficulty of obtaining empirical data. In particular, the potential impacts of pricing on economic activity in the affected and surrounding areas remain a concern. Some initial data are available on impacts in particular pricing locations, but additional data and study are needed.

Effective tools for communicating with and educating both policy makers and the public are still needed.

In the United States, resistance to raising the fuel tax and concern about the resulting transportation funding shortfall need to be addressed during the coming decade. Especially at a time when physical constraints make it harder than ever to build new capacity, pricing presents one promising alternative to the fuel tax. In light of pricing's success in ad hoc, project-specific applications throughout the world, it holds promise for inclusion as part of a broader and systemic solution to the coming funding situation.

In Europe, the contrary problem of far higher but uneven rates of fuel taxation has led the European Commission to advocate a greater standardization of transport financing through direct pricing of roads. The commission policy also notes explicitly that introduction of road pricing can either raise more net revenue by supplementing existing fuel taxes or raise an amount of revenue equivalent to that under the existing finance system through the use of tax rebates or refunds. Under either approach, road pricing is an effective means of managing demand on the road network.

## Potential U.S. Policy Initiatives for Further Discussion and Consideration

A number of potential policy initiatives were identified and discussed during the conference and in committee deliberations. Among those raised most often, the committee endorsed the following ideas as being worthy of further investigation and consideration; many are under consideration in pending legislation to reauthorize federal surface transportation programs:

- Providing broad permission for state and local officials to pursue pricing on new and existing federal-aid roads, including conversion of existing high-occupancy vehicle lanes into high-occupancy toll lanes.
- Continuing to house within the Federal Highway Administration a value pricing office or program to serve as an ongoing catalyst for research into pricing's potential under a range of conditions. The office or program would receive both funding to support and authority to award grants for preimplementation activities (e.g., traffic studies, surveys, and public education initiatives) and for the systematic evaluation of completed projects.
- Providing state and local officials with discretion to use revenues collected from pricing projects on federal-aid roads, bridges, and tunnels for any transportation improvement along the corridor or in the area in which the pricing in question has been applied.
- Permitting toll lanes or facilities on federal-aid routes dedicated to truck traffic and permitting longer combination vehicles to operate on these dedicated lanes or facilities with provision of adequate barrier or facility separation, subject to approval by the state and affected metropolitan planning organization.
- Establishing a special commission to examine means for funding transportation infrastructure through a long-range alternative to the fuel tax and consider the capacity of such an alternative to encourage efficient use of the existing surface transportation infrastructure. The commission's work would be expected to build on the findings of the ongoing Transportation Research Board Study of the Long-Term Viability of Fuel Taxes for Transportation Finance.
- Treating the federally tax-exempt status of parking and public transit subsidies equally and requiring employers who provide these subsidies to give employees who do not take advantage of these subsidies the nontaxable cash equivalent.

## Recommended Topics for Future Research

Ongoing research in the area of road pricing should include further consideration of the following topics:

- Pricing's impacts on the level of economic activity, land use patterns, and urban form of affected areas.
- Improved pricing structures for corridors and urban areas, especially with regard to pricing structures based on marginal cost.
- The impact of road pricing on freight movement, with such research based on surveys and analysis of implications not only for truckers but also for ports, terminal operators, and other parties participating in the logistics management chain.
- Empirical information on the distributional effects of pricing projects, with a focus not only on the incidence of the charges (i.e., who pays) but also on the relative distribution of benefits to individuals within a range of income levels, residential locations, racial and ethnic groups, and other relevant categories. The investigation should place such equity impacts in the context of the distributional outcomes created by the existing (i.e., largely tax-based) system for funding surface transportation infrastructure. Policy-based investigations of strategies, such as revenue recycling, to mitigate adverse distributional impacts are also recommended. Empirical evidence on locational and economic impacts should also be sought.
- Decision-making processes and constituency-building approaches that facilitate the implementation of pricing programs, including (*a*) consideration of the factors that influence various constituencies' and decision makers' views and (*b*) the impact of alternative institutional arrangements, including those involving the private sector, on the success of pricing projects.
- Successful practices through which transportation planners factor alternative pricing structures into an integrated transportation strategy, especially with respect to how the interaction of pricing structures with other elements of the overall strategy can help identify the optimal pricing strategy.
- The implications of increasingly widespread use of pricing on the development and adoption of appropriate technologies (e.g., toll collection procedures based on global positioning systems rather than dedicated short-range communications), with attention to both privacy considerations and the capacity of various technologies to maximize pricing's effectiveness.
- The range of existing and possible enforcement strategies to ensure compliance with toll provisions and high-occupancy vehicle requirements and an evaluation of their effectiveness and administrative feasibility.

## Recommended Activities to Promote International Cooperation

In the area of international cooperation, the committee identified a number of initiatives designed to take advan-

tage of the knowledge gained across the world in pricing projects:

- Encourage United States research institutions and the European Commission to pursue coordinated and, ideally, parallel research projects.
- Treat this symposium as a launching pad for similar international pricing symposia in the future to be held at regular intervals and to address a regularly updated agenda of topics.
- Create a centralized web-based repository of information on worldwide pricing projects. Possibly to be created and maintained by the Transportation Research Board, this website would include a regularly updated roster of priced facilities, the essential factual information about these facilities, and published papers and evaluations.
- Through a partnership between the Transportation Research Board, other U.S. institutions, the Organisation for Economic Co-operation and Development, the European Conference of Ministers of Transport, and other national governments and organizations throughout the world, sponsor a series of site visits to prime international examples of priced facilities. The visits should be directed to influential decision makers and convey the feasibility of such projects and the lessons learned throughout their implementation.

# Setting the Stage

# Welcoming Remarks and Charge to the Conference

Bob Oldakowski, *Mayor of Key Biscayne*
Lowell Clary, *Florida Department of Transportation*
Sherri Alston, *Federal Highway Administration*
Robert E. Skinner, Jr., *Transportation Research Board*
Martine Micozzi, *Organisation for Economic Co-operation and Development*
Steve Heminger, *Metropolitan Transportation Commission*

Participants were welcomed to Key Biscayne by the Honorable Bob Oldakowski, Mayor of Key Biscayne. He noted that the incorporation of Key Biscayne 12 years ago initiated a trend toward incorporation throughout Dade County and created a greater sense of autonomy and accountability for local decisions and recognition of their impacts. In keeping with the principle of responsible and beneficial policy choices, he wished the symposium's organizers and participants a successful conference.

Lowell Clary, Assistant Secretary of the Florida Department of Transportation, placed the charge to the conference attendees in the context of Florida's experience. The state has an extensive network of toll roads. More recently it has been examining pricing not only as a means of raising needed revenue but also as a tool for meeting other policy objectives, including managing congestion, optimizing the network, and addressing an array of concerns regarding the distribution of costs and benefits of the transportation system. He indicated that the state and the nation would need to undertake an extensive study of the gasoline tax within the coming decade to examine whether it ought to remain the backbone of the system for funding surface transportation investment or be supplanted by another mechanism for raising revenue. Given pricing's capacity not only to raise revenue but also to address other policy objectives, he said he thought it likely that pricing already has and will retain an important place in the overall system for funding and managing the transportation network.

Representing the Federal Highway Administration (FHWA), Sherri Alston described the congestion pricing pilot program established under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and continued as the value pricing pilot program under the Transportation Equity Act for the 21st Century. She noted that the pilot has brought pricing experiments to 36 projects in 15 states and is thus providing a wealth of information to help guide future policy decisions. She acknowledged several FHWA staff who had been particular leaders in the field, including Patrick DeCorla-Souza, and thanked them for their efforts in this area.

Robert E. Skinner, Jr., Executive Director of the Transportation Research Board (TRB), referred conference attendees to a 2003 publication on megaprojects (*Mega-Projects: The Changing Politics of Urban Public Investment*, Alan A. Altshuler and David Luberoff) and noted that one of the greatest challenges for jurisdictions undertaking these projects is to bring together diverse interests and develop a consensus concerning a common set of objectives and a plan for implementation. He noted that successful implementation of congestion pricing requires a similar harmonization of diverse interests and objectives, a short list of which includes the creation of new capacity, revenue generation, traffic calming, and environmental improvements. He said that he was pleased that TRB was revisiting the seminal *Curbing Gridlock* study and noted that the time is ripe for a fresh look at pricing.

Finally, Martine Micozzi, representing the Organisation for Economic Co-operation and Development, welcomed the many participants who had traveled from overseas to attend this symposium. She noted that this conference had an especially high level of international

participation, with overseas participants representing 15 countries from Finland to Australia. She noted that broad participation and the resulting cross-fertilization between various nations' experts on pricing would result in a much richer conference.

Following these welcoming remarks, Steve Heminger, Executive Director, Metropolitan Transportation Commission, Oakland, California, and conference chair, provided a brief overview of developments in road pricing since 1991. Starting with the U.S. experience, he noted that while ISTEA provided the first opportunity in the United States for limited experimentation with Interstate tolling and congestion pricing, most pricing successes have been in the area of high-occupancy toll (HOT) lanes, with projects under way in two California counties and Houston, Texas. While the San Francisco area was one of the early entrants into the federal congestion pricing pilot program with a proposal to institute peak pricing on the San Francisco–Oakland Bay Bridge, that project stalled for political reasons by 1994. Today, New York City has been able to do what San Francisco could not, with higher peak-hour tolls in place on the Hudson River tunnels and bridges into Manhattan.

The pricing provisions appearing in the Bush administration's proposal for reauthorizing the nation's highway and transit programs make incremental progress in a national policy that supports pricing, since they would allow local officials to institute HOT lanes anywhere on the Interstate highway system provided that the level of service is maintained for carpools and vanpools. Even in San Francisco, where officials have studied pricing without a single success, a HOT lane proposal for Interstate 680 may finally prove to be a winner. These trends largely bear out the findings and recommendations of TRB's *Curbing Gridlock* report, published in 1994, which concluded that road pricing was technically feasible and would produce a net benefit to society but had uncertain political viability.

Pricing seems to have fared better abroad, said Mr. Heminger. He named Singapore, Canada, France, the Netherlands, Norway, and England, with its exciting central London pricing project. It is also noteworthy that these applications generally involve "pure pricing," under which every motorist pays a fee, as opposed to the "choice pricing" of U.S.-style HOT lanes or express lanes, under which motorists can avoid the fee if they choose the free, slower lanes.

Providing the charge to the conference, Mr. Heminger called for a healthy exchange of ideas on all facets of road pricing, including technical feasibility, economic and social equity, and political viability. He concluded that the symposium provides an excellent opportunity for U.S. and international experts to learn from one another. He added, however, that in the area of pricing, the United States likely has far more to learn from abroad than vice versa.

# Road Pricing in Context
## The Efficient Allocation of a Limited Resource

Martin Wachs, *Institute of Transportation Studies, University of California, Berkeley*
Anthony May, *Institute for Transport Studies, University of Leeds*

The symposium began with two stage-setting presentations on the past, present, and anticipated future of road pricing.

### Then and Now: The Evolution of Transport Pricing and Where We Are Today

*Martin Wachs*

Obviously road pricing is nothing new—it has been around for at least 80 years. But has it yet entered the mainstream? Not quite, but pricing is at a critical juncture in North America and the United States.

In the United States, the first motor fuel tax was instituted in 1918, in the state of Oregon. The legislature had preferred a toll-based system of finance, but at the time it was rejected because of the cost of constructing booths and collecting the tolls. So a practical limitation, rather than a policy-based one, dictated the starting point for our system of paying for road infrastructure. This practical limitation has now been largely obviated by the advent of electronic tolling, which is one of several reasons for this being a watershed moment for congestion pricing.

Another factor contributing to the current state of affairs concerns the long-term viability of the fuel tax as a means of financing transportation. Road pricing was first suggested by the economist A. C. Pigou in 1920 and was expanded on by Frank Knight in 1924. In the 1960s and 1970s, the economist William Vickrey built on Pigou's and Knight's work and became an advocate of applied congestion pricing. However, the proposal could gather no momentum because the need for a stable funding base was already answered by the existence of the fuel tax. This condition may be changing, however, as the fuel tax's capacity to generate revenues gradually erodes because of climbing fuel efficiency and the reluctance of public officials at all levels of government to raise fuel or other taxes. Another key factor that may support greater use of pricing as a tool for managing demand rather than expansion of road supply is the frequent and potent opposition to plans for increasing road capacity through new construction. Environmental concerns and sticker shock from the high cost of new construction are forcing a more serious look at strategies for wringing the most mobility from the road infrastructure already in place.

In a way, the United States and Europe find themselves in a sort of "back to the future" situation, with revenue shortages and a view of user fees as a reasonable and appropriate pricing system hearkening back to the 1920s. The salient difference is the availability of technology today to make the pricing system almost invisible to motorists. The ability to charge for road use without cumbersome toll plazas and attendant traffic slowdowns and, more important, to vary charges on the basis of congestion levels has finally made true demand-responsive variable pricing a practical possibility.

Since the publication of *Curbing Gridlock* almost a decade ago, the United States and Europe have both pursued greater use of road pricing, but in quite different ways. In the United States facility pricing is most common, and we see it in the congestion pricing applications

on California's State Route 91 and Interstate 15. Some argue that many U.S. initiatives fall short of "true" congestion pricing in that they primarily add new options for motorists who choose to pay for premium service in lieu of establishing a consistent pricing system for all users. This approach, however, is consistent with and probably makes sense in the context of the decentralized transportation system in the United States. With the exception of older cities like New York and Boston, the United States does not have the same center city densities or geographic limitations that make cordon-style area pricing feasible in Europe. While Europe's experiments have included a few facility-based applications, it is more common to find area pricing applications that target center city areas. These differing approaches in the United States and Europe will probably carry forward into the future.

While we in the United States may well be on the brink of value pricing's entry into the mainstream, we should continue to heed lessons learned to date on conditions for successful implementation. The presence of widespread benefits and narrowly defined costs is one important factor for success. The proper use of revenue is essential to the public's understanding of a pricing project's impacts on equity, and dedication of at least a share of the revenue to public transport can counter the impact of road pricing on those with lower incomes. Finally, successful implementation of pricing programs almost always depends on the assembly and mobilization of diverse groups with shared interests to join public officials in championing the approach.

## One Step Forward, Two Steps Back? An Overview of Road Pricing Applications and Research Outside the United States

*Anthony May*

Road pricing is indeed coming into its own, and as Marty Wachs says, we are at a key juncture in its evolution. This is illustrated, in part, by evidence of more road pricing activity taking place in the past 10 years than altogether in the three decades before that. Thus, today, just 10 years after the *Curbing Gridlock* conference, we are in a position to structure a symposium around not only theory but also practice.

A review of European and Asian developments in road pricing since 1975, when Singapore established the world's first area pricing system, reveals three major approaches: (*a*) urban applications through area pricing in center cities, (*b*) priced toll rings surrounding urban areas, and (*c*) distance-based pricing on intercity roads. A look at the projects that have been proposed and implemented in the past 10 years in each of these three categories can be instructive for where we are now and where we are going.

- *Area pricing*. Singapore and London provide the oldest and newest examples of pricing entry into center cities. Despite London's system being new, it has been in the making for decades. Indeed, the Smeed report, published in 1964, set forth many of the criteria for success that still hold true. Subsequent phases in the evolution of London's consideration of road pricing included a "supplementary licensing" proposal in 1974; publication in 1988 of a congestion pricing strategy; a government-commissioned study from 1992 through 1995 of various charging schemes; and, ultimately, in 1999, the act that gave London's mayor the authority to establish a road charging system.
- *Toll rings*. In contrast to the cordon-based systems that charge fees for passage into a city center, tolls (to cross cordon) that encircle an urban center have taken hold in Norway. Tolls were introduced for the sole purpose of raising revenue and, as such, do not represent congestion pricing schemes but simply tolls. Norway is unique in that its system includes existing roads and charges at all entry points. While Norwegian officials are considering whether to convert to congestion pricing, it is doubtful that the current design can be adapted to demand management purposes.
- *Distance-based charging*. Seeking to combat congestion on intercity routes, Austria, Germany, and Switzerland are developing and implementing pricing systems that address the number of kilometers logged on major motorways. To date, these systems focus on heavy goods vehicles, partly in response to the continuing growth in freight traffic following the development of the single European market. Thanks to technological developments, Germany's system is currently shifting from a point-to-point assessment to a true distance-based pricing system. By the end of this year, the system will likely evolve from simple window stickers to the use of automatic vehicle identification through onboard units that will transmit the position of the vehicle, company and vehicle data, and the distance traveled on charged roads.

Despite, or perhaps because of, the tremendous progress of the past decade, several areas are ripe for further research. I'd like to suggest four in particular.

- Public acceptability, particularly with respect to the impact of the design of the particular pricing scheme on public opinion. One study found, for instance, that acceptance ratings for a proposed pricing scheme rose from 35% to 55% once the scheme included a commitment to dedicate the revenues to stated transportation uses rather than the general public coffer.
- Continued examination of various road pricing schemes' impacts on "vertical equity," which refers to

impacts stratified by income group, and "horizontal equity," which refers to impacts by geographic area and type of activity.

- Pricing's impacts on local economic conditions and land use patterns, for which there is little empirical evidence to date, in part due to measurement difficulties. While businesses tend to warn that pricing will produce job and income losses, the limited evidence we have to date suggests only minor impacts. Further evidence to refute or corroborate businesses' fears about road pricing would be most useful.
- The role of certain design features in different types of pricing programs. For example, when point-based pricing is considered, it could be useful to examine design features that may minimize diversion to alternative routes. Recent research in Edinburgh has shown a strong correlation between the benefits derived from pricing and the placement of charging points.

# Keynote Addresses

# Central London's Congestion Charging Scheme
## Has It Achieved Its Objectives?

Derek Turner, *Derek Turner Consulting*

On some occasions, a simple question—has the London charging scheme achieved its objectives?—can produce a simple answer, which in this case is yes. Since its implementation on February 17, 2003, the program has met all expectations, and the latest figures show that 60,000 fewer car movements per day are entering the center city charging zone, and about 110,000 people per day pay the congestion-based charge. Interestingly, 1 month after its implementation, Mayor Ken Livingstone, who was the program's tireless proponent, was receiving approval ratings 25 points ahead of his nearest rival.

The program was successfully implemented for a number of reasons, including political commitment, strong public relations, strong project management, and an effective procurement strategy. Equally important, the congestion charging scheme was put forth as one element of a much broader strategy that included signalization improvements, public transportation improvements, infrastructure repairs, and technological innovations; together these worked to demonstrate the government's commitment to the supply side of the transport equation, as well.

Once it was clear to public officials and the public at large that these supply-side investments were not sufficient to combat the choking congestion in central London, demand management became an obvious consideration. It is remarkable that the system, as eventually implemented, is not so different from the proposals that emerged from the Smeed commission back in 1964. Some 40 years later, we have found that congestion charging is one of the few policy proposals that can truly unite the left and the right, which in itself makes one of the strongest arguments for how essentially correct the proposal must be.

The benefits realized thus far are impressive. Journey times to, from, and across the priced zone are down by 14%. Time spent stationary or traveling at less than 10 kilometers per hour is down by 25%. Benefits are evident on the public transport side as well, with excess bus waiting times for routes serving the charge zone down by 33%. And in a side benefit that few made specific mention of early on, we are seeing fewer road accidents.

Revenues for 2003 and 2004 are projected at £68 million, and the mayor is using these revenues to boost investments in public transport, and especially bus service. In this way, congestion charging creates one of those rare but delightful virtuous spirals in which the consequences of one action create benefits that continue to build on themselves. This stands in stark contrast to capacity expansion, which serves only to create more demand and an ongoing cry for more and greater investment.

Because of the demand-side benefits that are so evident in the London program, I believe it is time to stop talking about fees, taxes, and tolls and instead start referring to demand management, variable pricing, and congestion charges. Above all, the London experiment has demonstrated that enthusiasm and a can-do attitude can deliver what is commonly viewed as an impossible project.

# Out on a Limb
## Pricing Futures

Kenneth Small, *University of California, Irvine*

The experience of the past 20 years has produced two major forms of congestion pricing: systems that focus on city centers and systems that target express traffic. Both forms of pricing can be shown to solve an array of problems. Congestion itself is the most obvious problem that road pricing addresses, but pricing can also be beneficial to public transit and can combat urban sprawl and related land use problems. Muddling through is, of course, an alternative to pricing, since congestion is at some point and by definition self-limiting. However, the costs exacted by a muddling-through strategy would be high indeed; as public officials and the public generally begin to understand these costs, road pricing can become more politically viable just as it is becoming more technologically viable.

The expanded use of pricing in the past 10 years can be attributed to several factors, including a growth in technical expertise and a keener understanding of the merits of the program itself. Lessons learned from past mistakes are also critical to making today's pricing proposals more viable than those of the past. As we examine the various applications of both forms of pricing, four major lessons emerge that can help inform the approach for the future.

First, as we look ahead, congestion pricing proposals are likely to develop as niche strategies. They will take advantage of differences among users in order to offer a type of service that appeals to particular segments of the population. The importance of such strategies is supported by recent research showing that user heterogeneity greatly affects the welfare evaluation and optimal design of value pricing schemes.

Second, additional pricing experiments can be expected in cases where the level of congestion is widely considered to be unacceptable. People are learning that there are no other feasible options for solving congestion. Solving congestion is not strictly necessary because it tends to be self-limiting; it is disliked and inefficient but not necessarily a problem of highest priority. In the United States, most experiments are likely to be incremental: changes in toll policy on existing toll facilities or addition of high-occupancy toll lanes or FAST[1] lanes. Elsewhere more large-scale experiments appear to be politically feasible.

Third, as large-scale experiments unfold, as in London, analysts will turn to measuring and documenting the effects on economic productivity. Some preliminary studies have suggested that a priced area need not necessarily become less attractive to business; theory suggests that how revenues are spent is important to this question. The relationship between congestion pricing and economic conditions is still poorly understood and stands as a prime area for further research.

Finally, where pricing is anticipated or in place as new roads are developed, we should begin to see changes in roadway design. Pricing shifts the trade-off away from the need to provide capacity and toward the desire to maintain aesthetic qualities and conserve scarce urban land. A result might be more parkways or "superstreets" designed for moderate free-flow speeds and moderate capacity. A speculative suggestion is that pricing might be used as a tool for limiting speed to make such road designs safer when traffic is flowing freely.

[1] "Freeing Alternatives for Speedy Transportation," a term used in legislation introduced in the House of Representatives in 2003.

# Special Topics

# Ah, the Politics of Pricing

Eric Schreffler, *ESTC, San Diego, California*
John Albion, *Lee County, Florida*
Jan A. Martinsen, *Norwegian Public Roads Administration*

## How Politics Affects Even Good Projects

*Eric Schreffler*

As part of the federally sponsored evaluation of the Interstate 15 Value Pricing Demonstration Project, ESTC prepared the institutional assessment, which involved interviews with some 40 stakeholders over the 3-year pilot project. Among other lessons learned, this review provides an interesting insight into how politically driven decisions concerning the use of revenue can lead to reasonably good but less than optimal results.

Jan Goldsmith, Mayor of the city of Poway, California, and the political champion behind the project, enabled the San Diego Association of Governments to move the dynamic pricing concept from idea to reality. His support for pricing grew out of his support for a monorail or other high-capacity transit service to solve traffic congestion problems on the main arterial in Poway as well as for expansion of the light rail system into the I-15 corridor. When planners told him that the demand did not exist for this type of service, he embraced the pricing concept as a way to pay for new transit service in the corridor. After moving on to become a state assemblyman, he sponsored the enabling legislation to allow tolls in the I-15 high-occupancy vehicle (HOV) lanes, which were effectively turned into into high-occupancy toll (HOT) lanes. To ensure that the funds would support the new bus service along the corridor, the legislation limited the use of the revenue to transit capital and operating and HOV facility improvements.

The evaluation of the pricing project showed that it improved the efficiency of the facility, did not seem to hurt carpooling, and cross-subsidized new transit service. However, the I-15 corridor bus service that provided much of the political support for the HOT lane approach did not necessarily fulfill expectations. The intent was to attract new bus riders in the corridor in order to remove cars from I-15. Instead, the new bus service attracted reverse commuters and riders who did not switch from driving alone. The service was split into two routes, one a new commuter express service that now attracts about 130,000 annual boardings.

How could the revenue have been spent to better fit the project goals and address congestion in the corridor? One promising alternative to subsidizing the operation of new bus service would be to provide a direct subsidy to the users of any alternative mode, including carpooling, vanpooling, bus, and teleworking. This would increase occupancy in the HOV lanes, which is still the primary purpose of the facility. The revenue could be used for general HOV marketing and to support commute alternatives, such as the county commuter express services. Use of the revenue solely for new transit service may have been a case where opportunity became expectation.

I-15 is widely accepted as a U.S. pricing success story, and properly so. The success is clearly due in part to the presence of a champion in Jan Goldsmith. However, could the project have been even more successful? Perhaps, had the revenue been used to subsidize all alternative modes rather than just a new service that did not meet many of its expectations.

## The Bridges of Lee County, Florida

*John Albion*

Lee County is one of Florida's most populous counties and home to several fine examples of value pricing. Several bridges in the county have had tolls in place for years, but gradually we have been developing policies under which the county uses targeted discounts to achieve demand management objectives. Two bridges are in play—the Cape Coral Bridge and the Midpoint Memorial Bridge. One of the key objectives was to encourage greater use of electronic tolling, and thus at nonpeak times drivers get a 50% discount if they use a transponder and pass. Upcoming changes include a 50% discount for vehicles with three or more axles, improved interoperability for the Sunpass and other automatic vehicle identification systems, and an expansion of the express lanes on the Cape Coral Bridge.

As part of this effort, public officials recognized several features that would be critical to successful implementation of the value pricing systems. Development of interoperable electronic tolling systems has been essential. A political champion is essential as well, but it is also important to create a cadre of "citizen politicians" to help spread the word in an enthusiastic fashion. In Lee County, one of our major efforts was to educate and garner support from community leaders before approaching the general public, and to do so in a straightforward manner that addresses basic questions, such as "What's a transponder?" before launching into the demand management philosophy underlying the proposal.

Business advisory committees, driver surveys, stakeholder task forces, and advisory groups were helpful in flushing out and addressing major areas of concern. Such concerns typically related to a full understanding of how electronic tolling works, how privacy considerations would be addressed, and whether value pricing would be effective in reducing traffic. We also benefited by building creative and fun elements into our public involvement strategy. These elements included naming contests and the use of lotteries and other incentives to encourage participation in surveys.

We have found a strong correlation between knowledge and acceptance, and today the system in place has a 70% approval rating. The other numbers generated from Lee County's experiments with value pricing are impressive as well, with estimated annual travel time savings totaling about 30,000 hours and associated financial savings to drivers of about $2.6 million.

## What Do Politicians Really Need to Know?

*Jan A. Martinsen*

For more than 50 years, Norway has successfully employed user charges to supplement regular government funding of road projects. In the past 20 years the use of toll road projects has increased considerably. Today, a good 35% of the total annual budget for road construction comes from more than 40 toll road projects scattered throughout the country. So far, about 100 toll road projects have been successfully realized, and only one has been declared bankrupt. User charges for road infrastructure funding in Norway are therefore considered a true success story.

Tolls are used to finance both urban and interurban road projects. In the three largest cities—Oslo, Bergen, and Trondheim—cordon tolls are the main source of funding for road and to a lesser extent public transport investment programs. In nonurban areas, toll financing is used only for road infrastructure investments.

The Norwegian government recently passed legislation to make congestion pricing possible, but so far it has not been implemented. The main road user charge issue in Norway today is whether cordon toll rings in the main cities can be transformed into congestion pricing schemes. Congestion and delays are well-known problems in some of these cities and represent a significant concern for professional advisors as well as politicians. The crucial question is whether the delays are big enough to be successfully managed through congestion charging. The average delay on selected routes in Oslo during peak hours is less than 10 minutes, with a maximum of more than 20 minutes for the most congested road. The transport professionals are convinced that congestion pricing should be part of future transport policy, at least in Oslo. The task is for these professionals to convince the political decision makers that congestion charging is a good policy.

The experiences in Norway so far offer some lessons for others wishing to implement road use charges. One of the crucial issues in considering the implementation of road user charges is the amount and detail of information that politicians need for their decision making. Of course, what they need to know and what they want to know might not be the same.

Our findings indicate that what the politicians need to know depends on the political level at which the changes are being considered (i.e., whether it is at the local or national level). While local politicians are more concerned with the use of collected funds to finance

infrastructure within their localities, national politicians are more concerned with the total government budget and ensuring that only financially sound projects are approved.

In Norway, each user charging scheme is approved by the national parliament on the basis of local recommendations. Therefore, what the local politicians need to know is crucial, and our experiences show the following:

- Local politicians need to know how road user charges will affect the local community, local business, land use, the environment, and so forth.
- They must gain something (e.g., more local transport improvements) from making unpopular decisions. Thus they need to know how revenue collected will be distributed in their local communities, including what percentage should return to road users and what percentage should be used for public transport.
- They need to know the costs of not implementing road user charges. For example, they should be apprised of how long they would have to wait for central government funds for the proposed improvements and what mobility consequences would be likely if nothing were done.
- They must be able and willing to deal with negative public reaction and to argue convincingly for the benefits from road pricing.
- They need to be shown examples of successful road user charging projects.
- They need a better understanding of how to interpret advice from transport professionals. At the same time, their advisors should make an effort to translate the economic theory underlying much of road user charges into simple language that everybody can understand.

Our experiences in Norway show that the implementation of user chargers is more likely to succeed when the factors described above are considered. Taken together, these principles can create a more productive and cooperative relationship between politicians and advisors that is based largely on a common understanding of the objectives of road user charges.

# A Closer Look
## Pricing Across the States

Mark Muriello, *Port Authority of New York and New Jersey*
Jim Ely, *Florida's Turnpike Enterprise*
Jeff Buxbaum, *Cambridge Systematics, Inc.*
Ellen Burton, *Orange County Transportation Authority*

### Toll Road Applications: Perspectives from the Port Authority of New York and New Jersey

*Mark Muriello*

The Port Authority of New York and New Jersey operates and maintains six interstate vehicular crossings, three bus terminals, the Port Authority Trans-Hudson (PATH) rapid transit system, the New York and New Jersey airports, and major marine terminals in New York and New Jersey. The authority is financially self-sustaining. It covers the operations, maintenance, and capital investment needs of its facilities through user fees, including tolls at the vehicular crossings.

On March 25, 2001, the authority introduced the Value Toll Pricing Program at the six tunnels and bridges that connect New Jersey with New York City. Since that time, the program has generated incremental revenue to support an aggressive intermodal capital investment program and has produced traffic management benefits to address congestion. The authority's Value Toll Pricing Program represents one of the most aggressive applications of value pricing on existing toll facilities in the United States. The program has generated meaningful steps in addressing traffic congestion through market incentives.

The overall goal of the program was to generate revenue to support a 5-year capital investment program composed of projects totaling $14 billion through a package of interstate tolls and fares sufficient to cover the deficits produced by the PATH transit system and the bus terminals. Five underlying policy objectives were established: (*a*) encourage traffic shifts to off-peak periods, (*b*) encourage use of mass transit and higher vehicle occupancy, (*c*) increase the number of E-ZPass electronic toll transactions, (*d*) create commercial traffic management incentives, and (*e*) eliminate frequency-based commuter discount programs.

Toll rates (in dollars) were set as shown in the following table.

| | *Cash* | *E-ZPass Peak (Weekdays 6–9 a.m. and 4–7 p.m.; Weekends Noon–8 p.m.)* | *E-ZPass Nonpeak* | *E-ZPass Weeknight (Midnight–6 a.m.)* |
|---|---|---|---|---|
| Automobile (eastbound only) | 6.00 | 5.00 | 4.00 | 3.50 |
| Truck (eastbound per axle) | 6.00 | 6.00 | 5.00 | 3.50 |

An effective stakeholder outreach and public communications plan was essential in advancing the program. In particular, we found that outreach to newspaper editorial boards paid tremendous benefits in educating the public and shaping opinion.

The program has met its revenue goals through its first 2 years despite the revenue forecast's overprediction of E-ZPass participation. To help refine the projections further, the authority has developed a new toll plaza–specific toll forecasting model to account for differences in markets, vehicle mixes, E-ZPass use, and temporal traffic distribution.

The project also has had some success in meeting its demand management objectives. The hourly percentage distribution of weekday traffic between 5 and 10 a.m. showed as much as a 2.6% increase (2,400 vehicles) in the first hour of the time period, just before the peak toll rates go into effect. There is less evidence that the off-peak discount has been effective in shifting demand to the hour following the 6 to 9 a.m. peak toll period. While similar results are evident during the weekday evenings, the effect is not as strong, which suggests somewhat less willingness to travel off-peak or flexibility in evening schedules. Also, there is little evidence that the off-peak discounts have been effective in influencing weekend travel patterns or overnight commercial movements.

In general, the sluggish New York City economy has dampened travel demand in 2003 in all time periods, and this year we have seen evidence of a shift back to the now less congested peak hours by early-hour off-peak motorists. This suggests that while the $1.00 discount has had some meaningful and sustainable ability to shift travel demand, its effectiveness in shifting demand to off-peak hours is highly correlated to continued levels of peak-period congestion.

Future toll rate adjustments are likely to seek smaller changes targeted by time of day, travel corridor, vehicle type, and managed roadway application. These may be less complicated to advance and provide an opportunity for smoother revenue infusion to sustain future financial needs. Another area for continued refinement lies in interagency coordination, especially given the large number of toll agencies in the New York–New Jersey region. Synchronized peak hours, jointly targeted market segments (autos, trucks), and coordinated E-ZPass customer statements could encourage continued behavioral change and maximize the pricing system's demand management benefits.

In closing, I offer a few observations on the future role for road pricing in the United States:

- New pricing projects will embrace a broader transportation improvement agenda, including transit, to create more travel options and customer choice.
- More time and resources are needed to help local initiatives take hold. In particular, local agencies will require resources to conduct continued outreach programs, educate the public, and manage opinion.
- Technical resources to establish and integrate tolling and charging systems are essential to advance value pricing today and prepare for future national transportation financing systems that are less dependent on the motor fuel tax.
- The federal Value Pricing Pilot Program remains critical to pricing's success, and upcoming federal highway and transit legislation should preserve it. The ability to price portions of the Interstate highway system under the pilot program should be maintained.

## Plans for Variable Pricing by Florida's Turnpike Enterprise

*Jim Ely*

Florida's Turnpike Enterprise, a largely privatized program of the Florida Department of Transportation, operates a 449-mile statewide system of toll roads.

One of the enterprise's most ambitious initiatives has been the development, distribution, and popularization of an electronic toll collection system; this technology is now recognized as a clear prerequisite for effective value pricing. It is also key to the turnpike's goal of broadly deployed "open road tolling," under which charges can be levied without impeding free and full-speed traffic flow.

The turnpike's electronic toll collection system is called SunPass. It is compatible with other electronic toll collection systems across the state. SunPass was recently opened to retail sales at certain drugstores and supermarkets statewide, and the sale of the millionth transponder was recorded in November 2003, just 4 years after the SunPass program's deployment. A key milestone was the achievement of statewide interoperability (E-Pass, O-Pass, SunPass), which occurred in 2001.

We believe that by 2004 more than 50% of system revenues will be collected electronically and that by 2008 participation will grow to 75%. We also anticipate that the turnpike will deploy an open road tolling system by 2008. Another key part the turnpike's plans is the development of a system of "Xpress lanes." These lanes are a new product for us, and the first of the Xpress lanes will be in the Orlando area on I-4. The turnpike is investing $250 million in the I-4 improvements, which will involve four priced lanes in the median. The project is the product of a partnership between the local Florida Department of Transportation office, the Federal Highway Administration, and the turnpike.

An opening date is anticipated for roughly 2015. Relying exclusively on electronic toll collection, the Xpress lanes will require a transponder and be value priced. Toll rates will be reasonable, between $0.06 and $0.20 per mile, and will be set by time of day to maintain Level of Service (LOS) C. Reasonable rates would

allow for affordability so the Xpress lanes can be "Taurus lanes" rather than "Lexus lanes." The decision to pursue value pricing was prompted by the recognition that future traffic demand in Orlando will be so great that general use lanes would fail even with the four-lane widening project. In contrast, value-priced Xpress lanes can guarantee LOS C by treating variable tolls as a congestion management tool.

The turnpike is simultaneously conducting a federally funded value pricing study for another project: the Sawgrass Expressway in South Florida. Of special note is that the Sawgrass project will involve a first-time conversion of an existing toll facility to open road tolling. The turnpike also recently completed a value pricing study on the Homestead extension of Florida's turnpike; this study concluded that the public's reaction to value pricing can be favorable if the proposed facility provides new capacity, as is the case with the Xpress lanes.

As we look at the full range of activities under way at Florida's Turnpike Enterprise, it is evident that value pricing holds significant promise as a congestion management tool suited to relieve some of the state's busiest highways.

## Mileage-Based Applications: Minneapolis, Minnesota

*Jeff Buxbaum*

The objective of this current research project in Minneapolis is to investigate whether the way we acquire access to a car can influence our driving behavior. Currently, people either own or lease cars and make other significant fixed payments, which encourage them to drive more to get the most from their investment. This project simulates the replacement of some of the fixed costs of ownership/leasing and operation with fees or charges based on mileage and perhaps time-of-day travel, to determine whether this influences their driving behavior.

The consultant team and the Minnesota Department of Transportation investigated the attitudes of the public toward mileage-based leasing products through focus groups. The focus groups indicated a segment of the population that would be interested in mileage-based leases. However, many people had a poor understanding of the cost to them of having and driving a car. Some people also had "big brother" concerns, although many others had no problem with that.

The original scope of work called for a hands-on test case under which a private business partner might be willing to test a new vehicle leasing product that included a mileage component. Ultimately, this approach was not feasible. The targeted partner decided that it did not want to pursue mileage-based leasing at the time, primarily because of concerns over cannibalization of existing lease markets and perceived customer acceptance issues.

The new work plan will take two tracks. The first will build on the work done in the focus groups and involve a comprehensive market research effort to understand who would voluntarily opt for mileage-based leasing or insurance. The goal is to understand the opportunities and constraints for real leasing or insurance products that might be offered by the private sector.

In the second track, the team will recruit a small sample of people who are willing to participate in a real-world experiment. They will simulate buying out the focus group participants' leases and insurance, converting their payments to a fixed component and a variable component, setting up a "budget" that participants can draw down, and paying them the difference between budgeted miles and actual miles.

Participants in the field experiment will be tracked for 10 months. Part of that time will be treated as a control period, during which the participants will receive no feedback on miles driven. An experimental period will follow, during which participants will be provided price signals on a semimonthly basis. The experimental period will test participants' responses to several variables, including total number of household vehicles, the number of vehicles included in the experiment, and variable pricing by time of day. Participants will be surveyed at various intervals in the project to identify shifts in their attitudes toward mileage-based pricing concepts.

This study design will serve two purposes. First, we will be able to compare the behavior of each participant's own control period with that participant's experimental period. Second, the control participants also will serve as a separate control group to those that are in the experiment period in order to identify any general changes in regional driving behavior that occur during the experimental phase.

The project is scheduled to end in September 2005.

## New Lane Applications: California State Route 91

*Ellen Burton*

The Riverside State Route (SR) 91 freeway is considered a land bridge between Orange County and the "Inland Empire" counties to the east. It is the only primary east–west corridor linking Orange County with the Inland Empire. The freeway carries more than 250,000 average daily vehicles, and during peak hours general-purpose lanes are highly congested. The current situa-

tion reflects a limited availability of affordable housing in Orange County but a strong job market. Orange County attracts daily work trips. Projections about future housing growth in the Inland Empire, coupled with a continued robust job market in Orange County, indicate that the existing jobs–housing imbalance and resulting transportation patterns will continue into the future.

In 1989, at a time when there was a scarcity of California highway construction, Assembly Bill 680 (AB680) authorized four public–private toll road partnerships. The 91 Express Lanes franchise was initially granted to the California Private Transportation Company (CPTC), and it became the first AB680 project built. The franchise extended from the Los Angeles–Orange County line on the west to Interstate 15 on the east. The franchise agreement included a noncompete provision, which was designed to protect bondholders. The provision constrained the construction of parallel roadway capacity for the 30-year life of the franchise agreement. In 1995, CPTC opened the 91 Express Lanes in the center median of the SR-91 freeway. Since that time, traffic has continued to grow in the express lanes and on the mainline freeway.

The 91 Express Lanes, which drivers may use for a fee, are separated from the general lanes by channelizers. The facility uses electronic tolling and has no intermediate access points. The purpose is to offer customers a choice for a safe, reliable, free-flowing trip. The facility uses variable pricing, which is set by direction, day of week, and hour. The 91 Express Lanes extend 10 miles from SR-55 on the west and the Orange–Riverside County line on the east.

The Orange County Transportation Authority (OCTA), as a county transportation commission, is responsible for planning and funding highway, street, and road projects, as well as delivering bus and rail transit services. In 2001 OCTA identified intercounty travel as one of the most pressing issues. One of the major corridors needing attention was SR-91; however, the noncompete provision that attached to the facility's financing was a significant limitation on any plans to increase capacity. OCTA's board of directors thus decided to pursue the acquisition of the 91 Express Lanes franchise to eliminate the noncompete provision.

In January 2003 OCTA bought the 91 Express Lanes franchise for $207.5 million. The transaction included the assumption of $135 million in taxable debt and the advancement of $72.5 million from internal borrowing. The first public policy change was to allow carpools with three or more persons (HOV3+) to ride free during all but "super peak" hours, Monday through Friday, 4 to 6 p.m. eastbound. During these times, HOV3+ riders pay 50% of the posted toll. Since the implementation of this policy in May 2003, HOV3+ use has grown 40% over the same period last year. Peak average vehicle occupancy has also increased from 1.38 before the policy to 1.48 in August 2003. However, HOV3+ revenue is down an average of $27,000 per week, and it is estimated that the policy will result in a decline of $1.4 million to $1.6 million in toll revenues annually.

OCTA next sought to refinance its taxable debt. To do so, OCTA needed to adopt a toll policy. Working with its legislatively created advisory committee, which is made up of public officials from both Orange County and the Inland Empire, a toll policy based on the concept of congestion pricing was developed. The policy used trigger points to manage peak-hour congestion to keep lanes operating at free-flow speeds. The goals were to optimize throughput while ensuring the financial viability of the facility. Tolls now are adjusted automatically on the basis of volume in the lanes. Since July 2003, tolls in four super peak hours have increased from $4.75 to $5.50 (eastbound Thrusdays and Fridays from 4 to 6 p.m.). Overall, year-to-date revenue has declined from about $2.70 per trip in Fiscal Year 2002–2003 to $2.40 per trip in Fiscal Year 2003–2004 because of the impact of the HOV3+ policy change.

In November 2003 OCTA refinanced its taxable debt and reduced the interest rate from 7.63% to 4.43%. This is expected to result in a present value savings of about $24 million over the life of the obligation. This is important because under state legislation passed at the time of OCTA's purchase of the 91 Express Lanes franchise, any excess revenues after debt service, operating costs, and capital costs are to be used on SR-91 improvements.

# Calculating Costs and Measuring Benefits of Pricing Schemes

Erna Schol, *AVV Transport Research Center, Netherlands*
Christopher Nash, *Institute for Transport Studies, University of Leeds*
Jeffrey Zupan and Alexis Perrotta, *Regional Plan Association*
Andrea Ricci, *ISIS, Italy*

## Costs and Benefits of Pricing Schemes for the Netherlands

*Erna Schol*

The Netherlands is currently dealing with the problem of growing traffic congestion. Economic growth, an increase in the number of smaller households, increased participation in the labor market, and limits on funding and physical space for new infrastructure all contribute to the growth of traffic congestion. While we have not yet implemented road pricing largely because of lack of public acceptance, road pricing is back on the national discussion agenda. In my view, it is all but inevitable that by 2010 the Netherlands will have some form of road pricing in effect.

As we renew our investigation into the long-term advisability of various road pricing schemes, a close look at pricing's benefits and costs is interesting. The benefits to be examined include direct benefits for road users, avoidance of external costs, and indirect benefits. Direct benefits include travel time savings due to reduced congestion, less welfare due to reduction of car mobility for system dropouts, and a shift of motorists to urban public transport. External benefits are realized through the avoidance of various external costs, including those imposed by emissions, noise, and traffic accidents and other threats to safety. Indirect benefits can be realized through impacts on the labor, housing, and automobile markets. Costs of a pricing system include the capital cost of the initial investment as well as ongoing operating and maintenance expense.

In a 1997 study the Economic Institute of the Netherlands applied cost–benefit analysis to two variants of road pricing: cordon-based area fees and fees levied on highways anticipated to be congested by 2001. Regardless of the variant, it was assumed that the tariff would be €2.25 and levied on both passenger and freight transport. The study concluded that given the assumptions, the cordon-based approach would yield greater net benefits.

In a Central Planning Bureau cost–benefit analysis conducted in 2001, two other scenarios were identified: (*a*) a variabilization of fixed costs through a per kilometer charge—essentially a flat rate based on the "pay as you drive" principle; and (*b*) a flat rate that included a congestion component—a surcharge of €0.10 per kilometer at times and locations of congestion. Both scenarios make use of an onboard unit and global positioning, so no toll collection points are needed. The total effect of the flat rate scenario is around zero, meaning that the costs are comparable with the benefits. The total effect of the congestion charge is positive and comes to about €10 billion by 2020, on the assumption of nationwide implementation of road charges for both passenger and freight traffic. This provides strong evidence that a congestion charge is effective in lowering transport demand and thus congestion. However, even the flat rate can decrease congestion (though to a lesser extent) if simpler, less expensive technology is used.

The broader lessons learned were that costs inevitably increase during the course of a project and that benefits can vary markedly depending on the structure of the pricing scheme, including the tariff level, the

potential to vary the charge in response to congestion levels, and the application of the scheme to an urban area generally or to highway travel. Thus, cost–benefit analysis can be a powerful tool for gaining insight into not only the advisability of a stated project but also the impacts of various refinements of a proposal.

## Why Reform Transport Pricing? An Overview of European Transport Infrastructure Charging Policy and Research

*Christopher Nash*

In its 1998 *White Paper on Fair Payment for Infrastructure Use*, the European Commission adopted a clear policy calling for the phased introduction of marginal social cost pricing for infrastructure use. It proposed legislation to implement this for commercial transport of all modes; the policy is confined to encouragement rather than legislation for private vehicles. For rail, the policy was implemented under Directive 2001/14, but for roads, the current proposal to revise the Eurovignette Directive on heavy goods vehicle charging falls short of this principle. It requires differentiation by congestion and environmental costs but ties the average level of charge to average infrastructure and external accident cost only. It is not clear whether this is to be seen as a step on the way to full marginal social cost pricing or as a change in policy.

Implementation of marginal social cost pricing requires that we be able to measure and value its three components:

- Marginal cost of infrastructure maintenance and operations imposed on the infrastructure manager;
- Marginal cost imposed on other infrastructure users in the form of congestion and accidents; and
- Marginal cost imposed on the rest of society, predominantly in the form of environmental costs but also some elements of accident costs.

Among the many criticisms of this approach is the complexity of measurements. A second major criticism is the view that charges should be tied to total costs rather than marginal costs, either for reasons of equity or dynamic efficiency. Several research projects have addressed measurement challenges and sought to clarify the impact of marginal cost pricing on different classes of vehicles and uses.

Participants in the Unification of Accounts and Marginal Costs for Transport Efficiency (UNITE) project estimated the total social cost of road transport for most of Europe and found that costs of congestion, pollution, and external accident costs totaled nearly 3% of gross domestic product, or double the level of infrastructure costs. Thus, charging solely to recover infrastructure costs is likely to lead to charges that are too low. But a further major issue is the inadequate differentiation of charges by vehicle type, location, and time of day; UNITE also undertook case studies to see how marginal social cost could be measured to identify those differences.

A number of projects (including Pricing European Transport Systems and Models for Transport Environment and Energy) have undertaken case studies that have predicted the results of marginal social cost pricing for all modes of transport. As would be expected, these typically show higher charges for the use of roads in urban areas, particularly in the peak period, with a fall in road traffic in the range of 5% to 20%, as well as changes in time and route of travel where pricing systems are sufficiently sophisticated to reflect these factors. For interurban traffic the outcome is more variable and reflects major differences in current charges and levels of congestion. Typically, cars are overcharged and heavy goods vehicles undercharged, but there are similar discrepancies in other modes so that the outcome of transport pricing reform is relatively limited in terms of changes in traffic volume and mode split. Transport pricing reform may thus be more important for interurban traffic due to its impact on vehicle type, time, and route of travel than for its effect on the overall volume of traffic.

## An Exploration of Motor Vehicle Congestion Charges in New York

*Jeffrey Zupan and Alexis Perrotta*

Currently 830,000 vehicles enter Manhattan's central business district (CBD) each day, and 78% do so for free. Of the 19 entry points to the CBD, four are tolled tunnels, four are free bridges, and 11 are free city streets and highways. The tolled tunnels are operated by two distinct authorities; both use electronic toll collection and one varies the charges by time of day. The free facilities are operated by the city of New York.

Our organization identified and assessed four pricing scenarios to highlight distinctions between flat and variable pricing, daytime and 24-hour pricing, and pricing at some or all of the entry points to Manhattan's CBD. The scenarios use the sensitivities of drivers who may respond to an added charge by not making the trip at all or by changing destination, mode, route of travel, or the trip's time of day. All four scenarios assume a cashless toll system and one-way inbound tolls:

- Toll East River bridges as does the Metropolitan Transportation Authority (MTA): a flat fee on East

River bridges set at the level of current tolls of the two parallel MTA tunnels;

- Variable pricing on East River bridges, MTA to match: variable time-of-day tolls on East River bridges with MTA tolls modified to match them;
- Like London: a pricing system at 60th Street for 13 daytime hours on weekdays with flat East River tolls during the same time period; and
- Full variable pricing: variable time-of-day pricing at all entries, including the East River bridges, MTA crossings, and 60th Street.

As modeled, these scenarios produce traffic reductions of 5% to 13%, with an even greater reduction during the peak period in the second and fourth scenarios. Drops in traffic would be higher at the East River entry points, which would likely lead to the virtual elimination of congestion at those crossings and relief on local streets in Brooklyn and Queens. However, such traffic reductions would result in only 0.3% to 1.0% fewer trips into the CBD and 100,000 to 270,000 more daily transit trips. All scenarios would generate substantial revenues in excess of $700 million, which could capitalize anywhere from $7 billion to $19 billion of new construction. Along with overall traffic volume reduction, pricing would provide benefits such as more reliable, stress-free driving; elimination of gridlock on local streets near crossings; faster speeds for necessary vehicles such as buses, taxis, and delivery vans; more space for amenities such as pedestrian boulevards; and funds for the next generation of transportation expansion.

Despite its benefits, pricing's opponents can be expected to raise concerns about economic impacts, geographic and income equity, and fairness to those with poor alternatives to driving. Many will claim that city streets and bridges simply should not be tolled. Pricing is especially politically difficult in New York, since 58% of the city council is from Brooklyn and Queens. Given these dynamics, four mayoral administrations have failed to win over opposition in the past. We suggest that next steps for New York should include agreement on objectives, a concerted effort to obtain support from the Bloomberg administration, further research, involvement from the business and media communities, and the development of a package of short- and long-term transit improvements that focus on Brooklyn and Queens.

## Relevance of Pricing to External Cost Calculation: Recent Results

*Andrea Ricci*

Externalities are changes of welfare caused by economic activities that are not reflected in market prices. External costs are those borne by those individuals who have not induced them. They remain such until they are incorporated, or internalized, in prices levied on those whose activities produced the externalities.

The European Union takes the view that transport pricing reforms should be based on the "users pay" principle, which would require full internalization of marginal external costs to arrive at the right price.

Two recently commissioned studies are helping policy makers zero in on ways to capture marginal external costs in transport pricing. The Real Cost Reduction of Door-to-Door Intermodal Transport (RECORDIT) project, funded by the European Union, has calculated the external costs of freight transport over more than 9,000 kilometers of network for both road and intermodal services. The UNITE project, also funded by the European Union, has carried out more than 30 case studies covering all modes and situations (urban and interurban freight and passenger travel).

Both projects address the most relevant categories of external costs: air pollution, noise, congestion, accidents, and global warming. RECORDIT has also developed rough estimates of life-cycle costs (e.g., production and disposal of vehicles, containers, and fuels). In addition, both projects address infrastructure costs, or the costs arising from wear and tear of the infrastructure itself, since these are a further component of the social costs to be passed on to the user.

The evidence produced by RECORDIT and UNITE shows the following:

- The methodologies currently used to calculate external costs are robust, especially for air pollution and congestion and, to a lesser extent, noise and accidents. Costs associated with global warming still suffer from large uncertainties.
- All categories of external costs are highly sensitive to situational factors (e.g., geographic position, meteorology, population density, and time of day). Particularly for congestion, this makes it difficult to transfer values from one context to another.
- RECORDIT has produced estimates of the average value of external costs for each European Union member state that take account of the specific characteristics of the national networks, vehicle fleets, and so forth. It has then derived the value of the internalization charge, as discussed below.

For the 16 European Union nations, RECORDIT identified external costs per kilometer imposed by a 40-tonne articulated truck. These external costs ranged from €0.24 (Sweden) to €0.54 (Slovenia), with an average of €0.32. The study further identified the extra charge per kilometer (compared with current taxes) that would be necessary to internalize external costs. These

ranged from a low of €0.17 (France) to a high of €0.35 (Switzerland), with an average extra charge of €0.21.

It can thus be concluded that the taxation and charging systems currently in place in the European Union do not cover the full social costs of transport infrastructure use, with shortfalls in the range of €0.20 to €0.40 per kilometer. Correcting current distortions in pricing practice requires the introduction of a variable per kilometer charge that could capture all important cost drivers, including vehicle technology and situational factors.

# Role of Pricing Revenue in Financing Projects and Services

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Robert Poole, *Reason Foundation*
Dario D'Annunzio, *Cofiroute*

## Lord of the Rings, Trondheim, Norway

*Erik Amdal*

Cities all over the world struggle with the same traffic problems: congestion, traffic accidents, and air pollution. This was the situation in Trondheim, Norway's third-largest city, with a population of 140,000. The main traffic problem in Trondheim was the lack of a road system with sufficient capacity to handle traffic demand. This caused traffic problems in the city center and the nearby residential areas. As much as 50% of the traffic in the city center was just going through the center without stopping. Between 1983 and 1987, traffic growth of 25% was registered, and it was easy to predict a total collapse in the near future if nothing was done to reduce the growth and improve the transport system.

In an effort to reduce these problems, in 1987 the city council decided to implement a road pricing or tolling system as one part of a new transport plan for the city. The transport plan covers all types of city transport. After extensive discussions with both local and central authorities, the national parliament approved a plan for extending the present main road system, building new roads around the city center, enhancing the road system for pedestrians and cyclists, and giving priority to public transport. It was agreed that the new investments should be financed partly by implementing a toll ring system around the city.

With an eye to the toll ring, policy makers emphasized the following goals:

- The toll or road pricing system should have low operating costs.
- The system should be used as a traffic regulation tool, with inbound traffic paying a higher rate during peak hours to distribute the traffic over time.
- The system should be based on a no-stop electronic payment system.
- The necessary toll equipment should be compressed to be suitable for all types of locations, even in the streets of the city center.

The following were key elements of the implemented system:

- Provision of free electronic tags to all car users in the Trondheim area,
- Operation of 10 unattended toll plazas and one attended plaza,
- Weekday operation of the toll ring system from 6 a.m. to 5 p.m., and
- Higher charges during morning peak hours.

The system opened on October 14, 1991. The Trondheim Toll Ring Project was well marketed before the opening, and today 95% of the motorists entering the city center use the electronic payment system. The revenues, today around 150 million NKr per year, are being used to finance new road infrastructure, improved public transit, and new facilities for pedestrians and cyclists in Trondheim. The first year after opening, inbound traffic during toll hours declined by 10% and weekday bus travel increased by 7%. In 1998 the system was

reworked to cover more traffic in the urban area. The city is now divided into six sectors, and vehicles crossing the sectors have to pay toll.

Today, the main traffic problems are nearly solved, and the traffic situation in the city center is significantly better now than 10 years ago.

More recently, in part because of a funding shortfall resulting from a cost overrun on the last city bypass, we expanded the toll ring again. Key elements of the revision included six new charging points and an increase in the base price. The new system is estimated to produce toll revenue of 200 million NKr per year, operating costs of 17 million NKr per year (representing less than 10% in operating costs), enough toll money to finance the latest round of investments in Trondheim's surface transportation infrastructure in 2005, and, most important, a solution to the city's current traffic problems.

## Bus Rapid Transit/High-Occupancy Toll Networks

*Robert Poole*

Many high-occupancy vehicle (HOV) lanes lanes throughout the United States are seriously underused; at most times of day, excess capacity exists on these lanes, which are dedicated to the use of vehicles carrying two or more (or three or more) passengers. The Reason Foundation has recently published a report on bus rapid transit systems and the utilization of high-occupancy toll (HOT) networks to reduce congestion and improve urban transit. Such lanes would continue to serve very high-occupancy vehicles, such as buses and vanpools, but would be available to lower-occupancy vehicle drivers who wished to pay a fee for access to these free-flowing lanes.

The report examines eight of the most congested U.S. cities to determine what infrastructure would be necessary to complete a cost-effective HOT network. Pricing on the HOT lanes would be variable, such that the price charged to paying vehicles would be high enough to limit traffic in the HOT lanes to a volume consistent with free-flow conditions. On highly congested freeways, this would produce peak-period, peak-direction toll rates in the range of 30 to 40 cents per mile. Buses and vanpools, as well as emergency vehicles, would use the lanes at no charge.

An analysis of potential revenues that would be generated and the debt that could be supported was conducted for each of the eight potential metropolitan area networks. In addition, the cost of building out the network was estimated by drawing on the long-range transportation plans of the respective metropolitan planning organizations (MPOs), supplemented by the authors. While some long-range plans omit high-cost HOV lane additions, many omit flyover connectors at freeway interchanges because of their high cost. With the availability of a new revenue source, these missing pieces were added to the plans proposed by the MPOs. The analysis showed that bonds backed by the HOT lane revenue alone could cover an average of 67% of the capital cost of constructing the new HOT lanes and interchange connectors needed to create a seamless network.

Put into practice, the concept could offer numerous benefits, including "congestion insurance" available to all motorists; reduced congestion in the general-purpose lanes; and facilitation of speedy, regionwide express bus service (bus rapid transit), all within the context of an infrastructure expansion that could be largely self-financing.

## Tolling the A-86 Tunnel in Versailles, France

*Dario D'Annunzio*

The A-86 is a ring road around Paris, the final link of which has yet to be built. Its intended length is 1,100 kilometers, of which about 900 kilometers has been completed. Traffic levels on the road have been rising, meaning that Paris is in much the same situation as most other major cities in developed countries.

The final link of the A-86 is expected to cost about €1.8 billion to complete. It will include two double-decked tunnels, with each level including two traffic lanes and one emergency lane. Charges levied on road users will repay capital costs as well as operations and maintenance expense. The fee structure is consistent with the facility's development and operation by a concessionaire. Total annual revenue is expected to reach €110 million by 2020. This projection is based on an optimal toll schedule that sets separate rates by time of day and day of week and that differentiates between single motorists and subscription motorists.

An opinion poll that surveyed 3,000 people gathered information on perceptions of factors that contribute to well-being and those that cause concern. On the basis of this information, we have developed communication tools that speak directly to the issues that are most important to those in the A-86 community. One of our most successful communication tools has been an A-86 West exhibition; we also publish and mail out an A-86 West newsletter.

In summary, through its development under a concession arrangement, the A86 West project brings to Paris a project that costs nothing to the national or regional government since it is financed wholly by Cofiroute. A flexible toll rate policy will encourage frequency of use and automated toll collection.

# Pricing Goes Global

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Marcel Rommerts, *European Commission*
Gopinath Menon, *MSI Global Pte. Ltd., Singapore*
Imad Nassereddine, *407 ETR Concession Company Ltd.*

## Variable Road Pricing in France

*David LeCoffre*

France has more than 50 years of toll road experience. Of the 5,000 miles of toll roads in operation, 4,500 miles are publicly owned and 500 miles are privatized. Tolling has always been viewed as a means to pay for construction, maintenance, and operation. The French government is now starting to look at methods for converting traditional tolls into variable charges that could not only cover the cost of infrastructure but also aid in traffic management and cover the external costs (e.g., environmental impacts) imposed by road use.

We define variable tolls as fees that are modified according to any number of parameters, including vehicle type, time of day, itinerary, environmental conditions, and the like. These parameters give rise to three special applications that may be useful under special circumstances. They comprise (*a*) time-variable tolls, which are based on the trip's time of day; (*b*) itinerary-variable tolls, which vary with the route traveled; and (*c*) environment-variable tolls, which are based on vehicle emissions levels.

The French government views variable tolls favorably. Several principles help guide the approach that the government is considering:

- Two users may pay two different toll rates if and only if they are in a significantly different situation;
- No revenue increase: any toll rate increases during a time of the day must be balanced by a comparable decrease during another time of day;
- Clarity and simplicity: the user must easily understand the implemented system; and
- Protection of the public interest: variable tolls may be used to enhance road safety.

Within the context of these principles, France is pursuing a pragmatic, step-by-step approach that is developing and will continue to develop on the basis of lessons learned from individual case studies. The experience of six such case studies, focusing on roads around Paris as well as some alpine tunnels, have resulted in peak-to-nonpeak traffic shifts of as much as 12%. Lessons generated from these and other case studies will prove invaluable as France moves forward with its European partners in forging new public policy by redefining tolls and determining the extent to which variable tolls should be used.

## Testing the Real-World Acceptance and Effectiveness of Urban Pricing

*Marcel Rommerts*

The European Commission is the administrative body of the European Union. The European Union has 15 member states and will be enlarged with an additional 10 member states in May 2004. Among its activities are setting common policy frameworks, harmonizing standards, and supporting information exchange and the management of a multiannual research, technological development, and demonstration activities program.

In the field of transport pricing, the European Transport White Paper, published in 2001, defines the following long-term policy objective: "gradually . . . replace existing transport system taxes with more effective instruments for integrating infrastructure costs and external costs." It goes on to identify charges for infrastructure use and the fuel tax as two such instruments. In recent months, the European Commission has presented proposals for directives on the charging of heavy goods vehicles on the trans-European transport network and on electronic charging systems. The last directive intends to move Europe toward satellite-based road user charging.

Over the past 10 years the European Commission has cofinanced a substantial body of research and demonstration projects in the field of urban pricing. The latest of these is the Pricing Road Use for Greater Responsibility, Efficiency, and Sustainability in Cities (PROGRESS) project, which is producing interesting results based on practical experiences. The majority of European cities testing road pricing thus far have not yet fully implemented their pricing schemes, but data are gradually becoming available. The following table shows the European cities that are starting to produce data; participants in the PROGRESS project appear in bold.

| *Development of Full Scheme* | *Full Pricing Scheme* | *Pilot/ Demonstration Scheme* |
|---|---|---|
| **Trondheim** | **Rome** | **Bristol** |
| Oslo | London | **Edinburgh** |
| Bergen | Durham | **Genoa** |
| | Stockholm | **Copenhagen** |
| | | **Gothenburg** |

These cities' approaches vary both conceptually and in the technologies applied. Some existing pricing programs (Trondheim, Rome) will be expanded on a trial basis during 2004. The plan in Stockholm is for a full-scale cordon pricing scheme that will be launched early in 2005. The Stockholm population will be able to give its views on the scheme in a referendum in 2006.

The experiences and conclusions of the different urban road pricing research and demonstration projects in Europe thus far can be summarized as follows:

- Urban pricing is possible with the use of existing and emerging technology. However, challenges persist. For example, further development of satellite-based technology is needed. In urban areas other technological or nontechnological solutions will need to be part of such systems. The European Galileo satellite network will improve satellite reception. The installation of the onboard equipment is complex, and retrofitting can cause problems.
- Pricing measures are effective in changing people's behavior and travel patterns. Experiences with the limited traffic zone in Rome show a 10% reduction of the daily traffic. A test in Bristol showed reductions of 15% to 20% in daily car travel during periods of poor air quality, mainly caused by car drivers switching to public transport. Car users change timing, route, or destination more easily than mode.
- By making pricing part of a package of measures, it can be made acceptable. Intelligent marketing and clear political leadership are essential. A lengthy and complex process can be necessary to gain support, and the media play a key role. Proposed approaches should have a clear purpose and well-defined objectives. Exemptions to the scheme are needed for equity reasons, and the management of exemptions can require significant organizational effort.

## Evaluation of Singapore's Electronic Road Pricing System

*Gopinath Menon*

In 1975, Singapore introduced a manual (i.e., nonelectronic) cordon-based road pricing system that used area licenses to control congestion in the city area. In 1998, this was converted to a fully automated electronic road pricing system (ERP) that uses a dedicated short-range radio communication system in the 2.40-GHz band. The ERP is in operation at 28 entry points into the city on weekdays from 7:30 a.m. to 7:00 p.m. and at 17 points along congested stretches of expressways and major roads on weekdays from 7:30 to 9:30 a.m.

Given the ERP's intent to charge vehicles for road use when and where they cause congestion, the system functions as a pure demand management measure.

Entry points have overhead gantry signs. All vehicles have fitted an in-vehicle unit, which is a pocket-sized transponder. Payment occurs via a smart card, which is issued by a consortium of banks. It is an active system in that deductions are made instantaneously from the smart card when the vehicle goes under the ERP gantry. The details of the last 25 ERP transactions are held in the smart card. Photographs of rear license plates ensure that drivers of violating vehicles have to pay a fine.

The capital cost of the ERP was S$197 million (US$1 = S$1.76). Annual operating costs are S$16 million, and annual revenue is S$80 million. The system has proved to be reliable over the past 5 years.

Different classes of vehicles pay different charges on the basis of passenger car unit equivalents. ERP rates are reviewed at 3-month intervals and are based purely on prevailing traffic speeds along the roads. The ERP aims to maintain a speed range of 20 to 30 kilometers

per hour on city roads and 45 to 65 kilometers per hour on expressways. Rates are increased or decreased when the average speeds for the 3-month period are outside the ranges.

We have found that the ERP has helped to spread traffic flow evenly over the working day and eliminate short, sharp peak periods—though some localized congestion for short periods remains along alternative routes and along the priced route immediately after the ERP stops operations. We have also found that the ERP has encouraged many drivers to consider public transport as a viable alternative.

In closing, I would like to indicate some prerequisites for a successful pricing program:

- Development and marketing of congestion pricing and demand management as part of an overall transportation strategy;
- Use of reliable and proven technology;
- A system that is easy to understand and use;
- Wide publicity for the system;
- Provision of acceptable alternatives, such as good public transport; and
- Special provisions or exemptions for foreign vehicles.

## E-407 Project in Toronto, Ontario, Canada

*Imad Nassereddine*

The $4 billion (Canadian) E-407 concession toll road is 108 kilometers (67 miles) long with 39 interchanges. It is located just north of Toronto, Ontario, Canada. The road has open access. No transponders or tags are required except for heavy vehicles (more than 5,000 kilograms), which must have a transponder. If a vehicle does not have a transponder, a video camera records a picture of the license plate and a bill is sent to the registered owner. This is true for all vehicles—even those registered in the United States.

The transponders both read and write, which allows for multiple entry and exit points. The tolls vary with type of vehicle, time of day, and day of the week. They start at C$0.1295 per kilometer for light vehicles. They double for heavy single vehicles and triple for heavy double vehicles.

The E-407 concession agreement allows for rates to be changed with 1 month's notice, but a fixed traffic flow must be maintained. Usage of E-407 has increased steadily from 180,000 vehicles per day in 1999 to 300,000 vehicles per day in 2003.

# "CarTrek"
## Integrating Technology with Pricing Schemes

Harold Worrall, *Orlando–Orange County Expressway Authority*
Kuniaki Nakamura and Nihon Doro Kodan, *Japan Highway Public Corporation*

### Technology and Pricing: Cause or Effect?

*Harold Worrall*

Are technology and pricing the cause or the effect? The answer is yes! An example of policy affecting technological development is the challenge that President John F. Kennedy made to America to "put a man on the moon and safely return him to earth before the end of the decade." In that instance policy served as a catalyst to a broad range of technologies, including transistors and integrated circuits. In contrast, the technology of radio frequency identification and its practical translation into electronic toll collection (ETC) strategies have served as a catalyst for road pricing in all its forms. As facets of policy and technology interact, new variants of policy and technology are created. The process is iterative.

A policy pyramid was presented that graphically identified the relationship of policy, funding, demand, and supply. Each face of the policy pyramid is interactive with the others, and the results of that interaction may catalyze yet other interactions. Funding policies may include tolling that affects demand and generates revenue, which may affect supply. Congestion pricing to affect behavior may also generate revenue for additional capacity—and not necessarily on behalf of the mode that generated the revenue.

Pricing's economic implications are broad. The long-held belief that public goods should be provided by public agencies may now come into question. The definition of public goods now becomes a question itself. A possible outcome of the new questioning process is the construction of transportation facilities through concession arrangements, much like those that have taken hold in many parts of the world since World War II. Who should pay for technological advances: government, the automobile industry, the insurance industry, or the consumer? Must technology have value for it to become ubiquitous in a free market environment? Information is itself valuable, and those who own the information may generate revenue for either the public or the private sector. What about liability? To what extent should government absorb liability through sovereign immunity?

Social equity is also a consideration in the application of technology. Critical to the success of new applications is the protection of private information in a free democratic society. The perceived threat of "big brother" is a chilling factor to many and can cause the rejection of otherwise reasonable public policy. Should technology be available to all or just those who are able to pay for it? Rawls's theory of justice would say that the protection of the minimum position could be violated by pricing concepts. This leads to the question of whether the disadvantaged, the elderly, and other population groups will benefit from pricing scenarios or be disenfranchised from transportation facilities because of it.

Finally, technological advances may "leapfrog" policies that are based on today's technology. Many lessons have been learned on how to implement technology. Clearly, the business strategy should lead the technological applications rather than the reverse. Politics and jurisdiction are externalities that frequently control the realization of the application of technology and should

therefore be considered initially rather than at the end of a project. The implementation of one application, ETC, has resulted in a paradigm shift in the toll industry.

Standards and regulations can also significantly affect the implementation of technology. Standards may also interact with jurisdiction, since the jurisdictional preference is dependent on each area's historical level and nature of investment.

## Electronic Toll Collection in Japan: A Wide Variety of Tolling Applications

*Kuniaki Nakamura and Nihon Doro Kodan*

Expressways extend throughout Japan, and all are tolled. While the tolls have been helpful in generating revenue, Japan's ongoing problems with traffic congestion and environmental degradation have prompted greater attention to the technologies that can help turn simple tolls into tools for demand management. ETC is a key factor in making congestion-based road pricing feasible.

The ETC system in Japan uses an onboard unit (OBU) and an integrated circuit card. Although Japan's expressways are operated by many public organizations, the same OBU can be used on all the expressways in the country. Our ETC system uses an active dedicated short-range communications (DSRC) system to carry out each transaction. We have found DSRC to be well suited to our needs given its expandability, high reliability, wide communication area, and efficient use of limited frequency resources.

ETC can be used at approximately 1,200 toll plazas throughout Japan. The number of installed OBUs exceeded 1.6 million by the end of October 2003, and 700,000 vehicles use ETC each day. ETC users account for approximately 11% of the total traffic volume. ETC service is scheduled to be available on almost all expressways by the end of this fiscal year.

Thanks to the capability provided by ETC, Japan is in the midst of experimenting with a variety of road pricing schemes, including environmental road pricing, special pricing for long-distance use, and special pricing for specific sections. Peak-period pricing and continuous-use discounts are under consideration. These road pricing schemes are expected to ease traffic congestion on expressways as well as ordinary highways and to promote the use of expressways. We expect that with further popularization and widespread use of ETC in Japan, increasingly effective road pricing strategies will be developed and tested in the coming years and that road pricing will become more prevalent throughout the country.

# Evaluation of Active Pricing Schemes
## Expectations, Revelations, and Illuminations

Donald Shoup, *University of California, Los Angeles*
Edward Sullivan, *California Polytechnic State University, San Luis Obispo*
Kristian Wærsted, *Norwegian Public Roads Administration*

### Lessons Learned from Paying for Parking

*Donald Shoup*

Employer-paid parking is the most common fringe benefit offered to workers in the United States, and 95% of American automobile commuters park free at work. Free parking at work amounts to a matching grant for commuting by car: employers pay the cost of parking at work only if commuters are willing to pay the cost of driving to work. Commuters who do not drive to work do not receive an equivalent subsidy. This matching-grant feature of employer-paid parking helps to explain why 91% of commuters drive to work and why 91% of their cars have only one occupant.

A few employers offer commuters the option to take the cash equivalent of any parking subsidy offered. Offering commuters the choice between a parking subsidy and its cash equivalent emphasizes that even free parking has an opportunity cost—the forgone cash. The option to "cash out" a parking subsidy raises the effective price of commuter parking without charging for it. Commuters can continue to park free at work, but the cash option also rewards commuters who carpool, ride public transit, walk, or bike to work.

California law requires many employers to offer parking cash-out if they subsidize commuter parking in spaces rented from a third party. The evidence suggests that parking cash-out produces significant benefits. Case studies in Southern California found that the solo-driver share fell from 76% before the offer of a parking cash-out to 63% afterward. For every 100 commuters, parking cash-out induced 13 solo drivers to shift to another mode. In another study, of the 13 former solo drivers, nine joined carpools, three began to ride public transit, and one began to walk or bike to work. With three times as many commuters switching to carpools as to public transit, we see that parking cash-out can reduce solo driving to work even in cases where public transit is not available.

Parking cash-out increased the employers' costs by only $2 per employee per month, because they saved almost as much on provision of parking spaces as they paid in cash to commuters. In addition, federal and state income tax revenues rose by $65 per employee per year because many commuters voluntarily traded their tax-exempt parking subsidies for taxable cash. And from a human resources perspective, employers praised parking cash-out for its simplicity, fairness, and role in helping to recruit and retain employees. In summary, parking cash-out provides benefits for commuters, employers, taxpayers, and the environment.

The cash-out provisions in California are unique among the states, however. Federal policy actually subsidizes solo commuting because federal tax law treats employer-paid parking as a tax-exempt fringe benefit. To solve this problem, I suggest one simple amendment to the tax code: condition the tax exemption for employer-paid parking on that employer's offering commuters the option to cash out. The nonitalic text quoted below is the Internal Revenue Code's existing definition of employer-paid parking that qualifies for a tax exemption; the italic text is the proposed amendment.

> Section 132(f)(5)(C): QUALIFIED PARKING—The term "qualified parking" means parking provided to an employee on or near the business premises of the employer . . . *if the employer offers the employee the option to receive, in lieu of the parking, the fair market value of the parking.*

Commuters who voluntarily choose taxable cash in lieu of tax-exempt parking subsidies will reduce traffic congestion, air pollution, and energy consumption—and will increase income tax revenues. Requiring employers to offer commuters the option to cash out their tax-exempt parking subsidies will reduce traffic congestion, conserve gasoline, improve air quality, increase tax revenues without increasing tax rates, and increase employee benefits without increasing employers' costs. A minor tax reform can provide all these economic and environmental benefits simply by shifting from a policy of subsidizing parking to a policy of subsidizing people.

## A LOOK BACK: CALIFORNIA STATE ROUTE 91

*Edward Sullivan*

The California State Route 91 Value-Priced Express Lane facility (91 Express Lanes) is a four-lane toll highway constructed in the median of an eight-lane urban freeway. The 16-kilometer express facility has no intermediate access and permits no heavy vehicles. Tolls are time dependent and reflect demand, with electronic toll collection only (no cash).

The 91 Express Lanes were originally constructed and operated by a private company under a franchise agreement with the state. The project came about because of legislation (California Assembly Bill 680) passed in 1989 by the California legislature to attract alternative funding sources to meet state transportation needs, gain private-sector efficiencies, and reduce congestion.

An impact assessment study took place from mid-1994 (about 1 year before opening) through 1999 to measure reactions to variable toll pricing and the other innovative features of the facility. Measured impacts included highway traffic changes; effects on corridor bus, rail, and park-and-ride usage; effects on accidents and significant incidents; origin–destination (revealed preference) surveys; opinion surveys; emissions modeling; and behavioral choice modeling. It was found that 91 Express Lane use strongly reflects hourly travel time savings, and peak flattening is only weakly responsive to tolls. Driving comfort and safety are often cited to justify paying tolls when time savings are minimal. Income correlates positively with use frequency; being female, middle-aged, and highly educated also correlates with greater use. Nevertheless, many frequent users are low-income, and many high-income commuters are infrequent users or nonusers. Toll incentives were associated with a long-term increase in 3+ ridesharing on the facility, and high-occupancy vehicle users appear generally more likely to use the 91 Express Lanes. Benefit–cost analysis shows that large travel time savings lead to a strong surplus of benefits relative to costs, which causes the 91 Express Lanes to compare favorably with other corridor improvement options.

In spring 2002, after some controversy related to ownership and severe parallel freeway congestion, the public Orange County Transportation Authority (OCTA) agreed to purchase the 91 franchise for $207.5 million. State enabling legislation allowed the OCTA takeover to become final in January 2003. In November of the preceding year, voters also approved Measure A to provide nearly $500 million in road improvements in the SR-91 corridor; these improvements had previously been blocked by the noncompete clause.

Despite its recent deprivatization, the SR-91 project has been and remains successful in many dimensions. It was an innovative model that helped establish an open mind toward market-based road pricing in the United States. It also proved that public–private highway partnerships can be financially successful. In my opinion, the Achilles' heel of the private project turned out to be the noncompete clause included in the franchise agreement.

The 91 Express Lanes have shown that innovative road pricing can be economically attractive, win public approval, and influence travel behavior. Increasing travel options is a subtle yet powerful outcome from such projects. One-size-fits-all approaches in road pricing have demonstrably failed. In contrast, increasing transportation choices through pricing has clearly succeeded and should regularly be considered in future facility planning.

## URBAN TOLLS IN OSLO, NORWAY: EXPERIENCES AND CONDITIONS FOR IMPLEMENTATION

*Kristian Wærsted*

The "Oslo Package 1," a user-fee-based array of projects comprising several urban main road tunnels, was developed as a means to build 50 projects over a 10-year period. Fifty-five percent of the financing comes from user fees, and the remaining 45% is composed of state grants. Had the system been funded entirely by the state, the same projects would have taken 35 years to complete. The Oslo Package 1 is a joint venture between Oslo (60%) and the neighboring county of Akershus (40%).

The toll ring covers all roads in three corridors that lead into the central part of the capital. The location of the cordons is a compromise balancing the highest possible income and a low number of plazas placed in areas where land could be acquired most inexpensively. The following are a few statistics. Fifty percent of Oslo's population live outside the toll ring. Average daily trips in the payment direction total approximately 250,000 vehicles. Annual toll revenues come to approximately 1 billion NKr; operating costs consume about 10% of the gross revenue. Eleven of 19 toll plazas are minor, meaning that they comprise just one lane for subscription members and one attended lane, while the other plazas have automatic coin machines to increase the capacity for manual payment. Lane capacity is approximately 1,600 vehicles per hour for electronic fee collection lanes and 300 vehicles per hour for the automatic coin machine and attended lanes. The largest toll plaza has three dedicated electronic fee collection lanes, three lanes with automatic coin machines, and one attended lane. Average daily traffic at this plaza numbers approximately 50,000 vehicles.

When the Oslo Package 1 was first proposed, transportation officials faced significant public opposition; opinion polls indicated that 70% of respondents opposed the toll scheme. Many visitors ask us how we were able to implement the package in the face of such opposition. We believe that the following are among the most important reasons:

- Bergen had already implemented a successful toll ring in 1986.
- Road traffic conditions had become congested to a choke point.
- The major political parties agreed to support the proposal.
- The proposal involved a limited collection period of just 15 years.
- Additional funding from the state was included as part of the plan.
- The plan involved relatively low toll rates.
- Eighty percent of all toll income is dedicated to investment in road infrastructure; the remaining 20% is earmarked for public transport infrastructure.
- Opponents of road construction and automobile use appreciated that the user-pays principle was being applied to motorists.
- The opening of the Castle Tunnel, the major tunnel in the Oslo Package 1, 2 weeks before toll collection began provided a positive signal to opinion. This six-lane tunnel removed Oslo's most severe bottleneck in front of the Oslo city hall and demonstrated to drivers that they would get something back from the package.
- None of the toll stations was expected to create bottlenecks, since their capacity was calculated to be higher than that of the adjacent road network. This proved to be true after the opening of the toll ring.

Toll collection in the Oslo Toll Ring expires in 2007, and the big issue now is whether it will be removed, extended (as happened in Bergen), modified to accommodate time-differentiated congestion pricing, or replaced by another type of road pricing scheme. A project group is now working on an Oslo Package 3, so time will tell. New electronic fee collection technology (AutoPASS) is being introduced, and contractual and operational interoperability for all electronic fee collection lanes in Norway will be implemented in February 2004. At that time fully automatic toll plazas enabling free flow through the plazas will be introduced in Bergen and Tønsberg. In this new concept, drivers without an AutoPASS will be videoed and billed monthly for the exact fee. If the approach turns out to be successful, it may form the basis for the future of toll roads in Norway.

# A Closer Look at the Real World

Derek Turner, *Derek Turner Consulting*
Stephen Ison, *Loughborough University, United Kingdom*

## Managing the Streets of London

*Derek Turner*

The use of congestion charging as an effective tool for the management of urban traffic flows has been demonstrated by the ground-breaking scheme introduced in London in February 2003. Many world cities that have already implemented new interurban toll routes are considering such a congestion charge as a method of extending road user charging to an existing urban road environment. Congestion charging is particularly relevant to the city's environment because, correctly managed, it initiates a self-perpetuating cycle that encourages a shift from private to public transport within the charging zone.

This method of charging is not a tax; rather, the charges are part of an integrated approach that incorporates improvements in public transport and highway facilities. The reduction in traffic allows buses to move more freely, and the significant portion of net revenue spent on buses provides increased capacity and frequency of service. The enhanced service is vital to ensure that former car users remain loyal to public transport in the long term.

The central London congestion charge scheme requires purchase of a virtual area license to drive within a 21-square-kilometer area of inner London. Cameras linked to automatic number plate technology capture vehicle registration plates on entry into the zone and store details in a database until matched to a payment. The payment is applicable during weekdays from 7 a.m. to 6:30 p.m.

Strict enforcement and a thorough monitoring strategy have enabled a successful launch and efficient ongoing performance. The world's largest congestion scheme has prompted favorable comments, such as the following by Susan Kramer, a board member of Transport for London and a previous mayoral candidate: "We always thought we had to live with congestion in our city centers. London has shown this is no longer true."

Results after 6 months of performance have shown a multitude of improvements for London's transport: a 25% decrease in time spent stationary; a 30% reduction in traffic delays; and a 14% reduction in journey times to, from, and across the charging zone. Reduction in inbound traffic flow has been most evident in peak periods, with weekday speeds in and around the zone increased by 10% to 20%.

London's buses have seen a 33% decrease in excess waiting times for bus routes serving the congestion charge zone. Bus delays due to traffic disruption have been halved both inside the zone and on the ring road that forms the zone boundary but does not incur a charge.

A reduction in road accidents has also been measured, though a longer period is required to determine its significance. The net revenues (i.e., revenues after deduction of operating and enforcement costs and debt payments) of the scheme are expected to be £68 million for 2003–2004 and are expected to rise to between £80 million and £100 million in future years. The annual net benefits, exclusive of these revenues, are forecast to be £50 million. They include considerations such as time savings, fuel savings, and reliability benefits.

## Failed Schemes in Pricing

*Stephen Ison*

While London's experience with congestion pricing is typically viewed as a success story, it is important to pay equal attention to pricing schemes that have not made it to implementation. Experiences in Hong Kong and Cambridge, United Kingdom, provide two prime examples.

Public perceptions of the depth of the problem and the costs of addressing it played an important role in both instances. While people frequently complain about traffic, often the public as a whole does not think congestion levels bad enough to warrant major policy initiatives, particularly when they perceive that the costs of the initiative will be too high.

In addition, many people suspect that congestion pricing is aimed at not only financing infrastructure but also paying for general policy objectives. For this reason, surveys frequently find that if the respondents are confident that revenue will be used for a specific transportation-related purpose, such as public transport, they are more likely to support a congestion pricing initiative. Mistrust of government, and particularly suspicions that a commitment to use revenue for a particular purpose will be overturned in the future, can easily undermine support for any pricing program. In terms of congestion pricing in central London, the revenue generated is earmarked for transport-related projects. This is also the case for any other authority considering the implementation of a congestion pricing scheme in England and Wales in line with the Transport Act (2000).

Other public concerns, which often extend to political leaders as well, revolve around privacy and the reliability of the technology on which the pricing system relies.

An examination of London's experience helps illustrate conditions that may be necessary, though not sufficient, to move from a proposed system to implementation. Among the essential ingredients are the following:

- *Severity of congestion*. In London, speeds had been declining since the 1970s, and in an amount sufficient to make the magnitude of the traffic problem obvious to all road users. (Interestingly, this suggests pricing's greater potential as part of a solution to address existing congestion than as a preventive measure.)
- *Strategic exemptions*. To underscore the program's policy objectives and address equity concerns, London's pricing policy excuses certain residents, alternative fuel vehicles, emergency vehicles, vehicles with nine or more seats, emergency vehicles, and vehicles driven by disabled people from the fee.
- *Clarity of objectives*, with an explicit line drawn to transport demand management.
- *Proper hypothecation, or earmarking, of revenues*. A pledge to dedicate revenues to public transport was a popular choice given the public's widespread perception of its current financial needs outstripping available resources.
- *Easily understood technologies*. While it may be necessary to refine the fee collection system at a later date, a pricing system is more likely to be adopted if the initial system is simple and can be explained quickly and clearly to the public at large.
- *Single implementing agency*.
- *Charismatic advocate*. Obviously, the presence of a leader such as London's Mayor Ken Livingstone can be key to successful implementation. The case of London is especially interesting, since congestion pricing provided the opportunity for a left-of-center politician to seize on a market-based proposal early in his term and stake his reputation on the proposal's success.
- *Strong presentation*. London's pricing advocates did an excellent job of engendering trust through open communications, a clear and well-composed presentation of the problem and the proposal, and the development of first-rate communication tools, including a highly effective website.
- *Weak opposition*. A final factor working in London's favor was the relative absence of any sustained organized opposition to the proposal.

Some of these conditions are within policy makers' and program managers' control, while others cannot be manufactured. Without a clear understanding of those factors within and beyond their control and how those factors will bear on ease of implementation, the possibility of replicating London's experience through fortunate circumstances and lucky breaks will be remote indeed.

# Impacts of Pricing on Interurban Freight Transportation

Robert Poole, *Reason Foundation*
Tony Wilson, *National Transport Commission, Australia*
Darrin Roth, *American Trucking Associations*
Andreas Kossak, *High Commission Financing the Federal Transportation Infrastructure, Germany*

## Toll Truckways: Using Pricing to Finance New Goods-Movement Infrastructure

*Robert Poole*

The United States faces a serious shortfall in highway investment as fuel taxes fail to keep pace with inflation, increased fuel economy, and use of alternative fuels. Trucks deliver 90% of the value of U.S. freight, and there is little likelihood of a significant mode shift to rail for a variety of reasons. The problem addressed in this presentation is how to expand long-haul highway capacity to meet the needs of goods movement.

Historically, the trucking industry has opposed any expansion in the scope of tolling on the grounds that paying both tolls and fuel taxes on the same highway constitutes double taxation. Whether fuel taxes paid by heavy trucks fully cover their fair share of highway costs can be debated, but the fact is that political opposition to tolls by the trucking industry has been a significant obstacle to wider use of tolls to fund improved highways.

Recent work at the Reason Foundation has posited a new approach to tolls and trucking. The basic concept is to provide significantly more valuable highway services to heavy-duty long-haul trucks to make it worth their while to pay tolls. The key insight underlying this approach is that double- and triple-trailer rigs make possible major increases in trucking productivity. But these longer combination vehicles (LCVs) are banned by federal law from most parts of the National Highway System. The federal "LCV freeze" permits LCV operations only on routes that were available to these trucks under state laws as of 1991. Thus, higher-productivity LCVs operate only on selected western Interstates and a few eastern turnpikes and toll roads.

The Reason Foundation's researchers propose that LCVs be allowed to operate on new, barrier-separated heavy truck lanes that would be added to selected Interstate routes, generally to fill in missing links in the fragmentary LCV network or to extend that network to new destinations. Trucks would be charged tolls to use these new truckways and would be allowed to operate as LCVs only on these special lanes (in states covered by the LCV freeze).

Simulation modeling was carried out on the basis of a heavy-duty pavement design, a model of pavement wear and maintenance, and a variety of scenarios, including both standard 18-wheel single-trailer rigs and long turnpike doubles. It was assumed that trucking firms would pay a toll of as much as 50% of the cost savings that would result from higher-capacity rigs. The resulting analysis found that, over a wide range of scenarios, toll truckways would be economically and financially feasible.

The idea is now being considered by Congress as part of reauthorization of the federal surface transportation program.

## Overview of Studies on Heavy Vehicle Charges

*Tony Wilson*

Road use, like many other activities, has traditionally been regulated on the basis of a set of prescriptive rules.

For example, a particular type of axle might be limited to carrying a set mass. This type of rule provides a blunt, indirect means of limiting the amount of pavement wear a vehicle can produce and may also be used as an indirect means of ensuring that the vehicle is stable and safe.

As a result of these blunt rules, the approach in Australia, as in other countries, to pricing road wear has been to rely on aggregate systems rather than to measure the vehicle's use and resulting road wear directly and price it accordingly. The Australian road pricing system for heavy vehicles aims to fully recover their share of road construction and maintenance costs through a two-part pricing system comprising a fuel charge and fixed annual registration charges that vary by vehicle type and size. The prices are based on average utilization for each class of vehicle—average mass, average distance traveled, and average fuel consumption rates.

Consequently, we, like others, have not had to develop a good understanding of the relationships between road use and infrastructure costs. More research in this area would be useful, but for the time being we in Australia have relied on the original American Association of State Highway and Transportation Officials tests of the fourth-power law to estimate the pavement wear contribution of different axles and loads, with load equivalencies derived from a system of measurement different from that used in pavement design. However, this approach provides little understanding of the variations that can result from different pavement designs, traffic levels, and environmental conditions. The European National Highway Research Laboratories COST 334 project has advanced understanding of a number of issues, but many questions remain.

While the long-standing blunt, prescriptive approach to regulating road use creates little incentive to shift away from a broad, aggregated approach to pricing, Australia is gradually making this shift. There are three main planks to this new, less prescriptive approach:

1. Development of a performance-based approach to regulating safety and infrastructure outcomes of heavy vehicles. The new approach will operate as an optional alternative to prescriptive mass, dimension, and configuration rules for the time being. It directly specifies the safety and infrastructure outcomes that vehicles are required to achieve.
2. A broad range of compliance and enforcement reforms that attempt to put in place an enforcement strategy that aims to promote compliance. The reforms separate offenses into risk bands depending on the potential negative impacts of noncompliance and make available a commensurate range of penalties. These provisions have no precedent in Australia or overseas and will oblige all parties in the supply chain to take steps to prevent a breach of the road transport mass and loading laws.
3. The Intelligent Access Program, which is developing ways of using vehicle-tracking technologies to monitor the route compliance of heavy vehicles on Australian roads. This approach provides greater confidence that vehicles use the roads they are meant to use. It provides a mechanism to allow more extensive access for vehicles operating outside the norms of the vehicle fleet, such as mobile cranes, vehicles operating under mass concessions, dangerous goods vehicles, or other specialized or innovative vehicles.

As a result, we are now in a position to start examining more flexible approaches to regulating road use, but they will be acceptable to infrastructure managers and the community only if they are accompanied by variable pricing arrangements. By the same token, other interest groups will seek and accept variable pricing systems of this type only if there is a change to more flexible regulatory approaches.

The following are examples of more flexible regulatory arrangements:

- Allowing heavy vehicles to choose what mass to operate at, within safety limits;
- Allowing heavy vehicles broader access to a range of roads or routes from which they are presently restricted;
- An improved method for managing the impacts of land use changes that could necessitate additional heavy vehicle road use and create consequent impacts on the transport infrastructure; and
- Applying pricing to allow optimum use of multiple transport modes in the total supply chain from origin to destination by accurately charging for the road link in the transport chain.

The mechanisms to allow this type of incremental pricing system in Australia are currently being developed and analyzed. The appropriate design is expected to be chosen over the coming 12 months, with work following to put the new system in place by around 2006.

With these developments, Australia will be in a position to consider whether broader social costs of road use should be incorporated in the pricing arrangements. Inclusion of these other costs in the calculation would represent a significant shift in the objectives of a pricing approach, which would need to be carefully considered to ensure that the resulting pricing system is best suited to the objectives to be achieved.

## Effects of Pricing on Trucks in the United States

*Darrin Roth*

The American Trucking Associations is a national federation representing the trucking industry. Its views on

road pricing center on a key distinction: mandatory versus voluntary systems. It supports the concept of voluntary tolls but is leery of the slippery slope whereby voluntary systems gradually morph into mandatory systems. Without adequate assurance that voluntary really does mean voluntary, the industry would look at most pricing proposals with a good degree of skepticism.

Incentives that permit the industry to improve its productivity—for example, through adjustments to size and weight limits—can help mitigate industry doubts about the extent to which pricing will benefit truckers rather than simply raise revenues. Indeed, recent history has witnessed a large number of unacceptable policy decisions, including an 82% rate increase on the Ohio Turnpike and a 300% increase on seven toll bridges crossing the Delaware River. We have ample evidence that revenue generation, rather than productivity improvements and other benefits to road users, underlie many pricing ventures.

Another of the industry's concerns is double taxation. Without a doubt, truckers already bear a sizable tax burden. A true user fee should be based on the true cost of the vehicle's use of the facility, with revenue funneling straight back into the facility. This principle is utterly overturned when a user fee is imposed over and above an existing tax system. Similarly, the industry's support for any pricing project is also predicated on the appropriate use of revenues generated by the project. In our view, revenues are legitimately directed to the service of debt and the expense of operating the facility; tolls should be removed once bonds are paid off. Certainly, revenues generated by a given facility's users should not be directed to any unrelated facility or purpose.

And what is pricing's true effectiveness in modifying behavior and managing demand for a limited resource? Given shippers' expectations for pickup and delivery times, truckers have little control over their travel times; as it stands, truckers seek to avoid peak times anyway, even without price signals to force the issue. Also, traffic diversion can quickly undermine the true goals of any pricing project. One recent study predicts that with a toll increase of $0.20 per mile, up to 50% of truck traffic can be expected to divert to alternate routes. Another study, performed by Fluor-Daniel, demonstrated that under a new pricing project under which trucks and cars would face tolls of $0.17 and $0.05 per mile, respectively, 35% to 85% of vehicles would divert. And that 82% toll increase on the Ohio Turnpike underscores the diversion concern as well; following the increase, local roads suddenly experienced a 30% to 50% increase in truck traffic. Such diversion can obviously impose significant safety, environmental, and infrastructure costs.

Finally, electronic tolling imposes significant costs on truckers; if the German road pricing proposal were applied to the United States, we estimate that it would cost $200 million per year to place onboard units into new vehicles and $1.5 billion to convert existing vehicles. The fuel tax, in contrast, imposes much lower ancillary costs.

While the American Trucking Associations is open to proposals such as the truck tollways currently proposed by the Reason Foundation and the conversion of high-occupancy vehicle lanes to high-occupancy toll lanes, our support is wholly dependent on assurances that the proposed pricing will be voluntary rather than mandatory and make provision for alternate routes for truckers who are unable to pay any newly imposed fee.

## Tolling Heavy Goods Vehicles on Germany's Autobahnen

*Andreas Kossak*

In 1999 the German government decided to introduce distance-related charges for heavy goods vehicles (HGVs) starting in 2003. This decision stemmed from at least three goals: to raise additional money for financing the federal transportation infrastructure, to shift freight transportation from road to rail and inland waterways, and to improve the competitiveness of the German logistics industry.

A High Commission on Financing the Federal Transportation Infrastructure was appointed and given full discretion to develop recommendations on financing strategies. The commission's central recommendation was to convert "the financing of the Federal Transportation Infrastructure . . . step by step from financing on the basis of the Federal Budget and federal taxes respectively to financing by the user—as far as possible under the different boundary conditions." With regard to the technical system for charging the toll and the amount of toll, respectively, the commission recommended that "the system should ensure upward-compatibility and interoperability" and that "HGVs should be charged an average toll of 25 Pfg. per vehicle kilometer on Autobahnen."

By the end of September 2002, the national government had made a final decision for the operator of the tolling system and had decided to allocate 50% of the net toll revenue to the railways and the inland waterways. At present, we expect the tolling system to take effect in spring or summer 2004.

Throughout this process, the logistics industry has not registered significant opposition to tolling HGVs using Autobahnen on the basis of internal costs. In fact, many in the industry hold that the introduction of the tolling system will be beneficial, since it will improve the competitiveness of the German logistics industry compared with that of the foreign truckers using Germany's Autobahnen, which are exempt from the relatively high

German traffic-related taxes. The industry, however, has called for the exclusive dedication of the total net revenues for improvements to the federal roads system. In addition, it emphasizes that any additional financial burden must be passed on to the clients.

We expect that qualified logistics enterprises will increase their productivity, though simple freelance truckers may suffer some setbacks. We also expect that an increase in transportation fees will raise consumer prices. And finally, we expect almost no shift of freight from road to rail, though a substantial shift from Autobahnen to toll-free "Bundesstraßen" is possible. This phenomenon could lead to pressure to expand the tolling to other types of roads.

# Winners, Losers, or a Zero-Sum Game?
## The Distributional Impacts of Pricing Schemes

Peter Nelson, *Resources for the Future*
Farideh Ramjerdi, *Norwegian Institute of Transport Economics*
Douglass Lee, *Volpe National Transportation Systems Center*

### Welfare and Distributional Effects of Alternative Road Pricing Policies for Metropolitan Washington, D.C.

*Peter Nelson*

Like many metropolitan areas in the United States, the Washington, D.C., region has recently experienced rapidly worsening traffic congestion as well as difficulties in finding revenue to finance improvements to the transportation network. As a consequence, local policy makers have directed their attention to high-occupancy toll (HOT) lanes as a cost-effective way to provide additional capacity. Currently the governments of both Maryland and Virginia are examining the viability of implementing HOT lanes on a variety of local facilities.

Concerns about so-called Lexus lanes have arisen in the Washington area in the past. In 2001, Maryland Governor Parris Glendening killed a HOT lane project because of concerns that it would be unfair to lower- and middle-income drivers. To test this assertion, we at Resources for the Future modeled two scenarios by using the Washington START model, which is based on the START modeling suite developed MVA Consultancy.

START is a "strategic" model and is characterized by an aggregated treatment of the transportation network and a highly detailed characterization of transportation demand. Its flexibility, quick run times, and consistency with household optimization theory make it useful for policy research. One of its attractions is that it can account for policies' "adjustment costs" (e.g., the cost of switching from on-peak to off-peak travel to avoid paying a toll).

Two scenarios were modeled: a HOT lane policy and a more comprehensive road pricing policy. Under the HOT lane policy, all of the region's high-occupancy vehicle (HOV) lanes were converted to HOT lanes that solo drivers could use for a 25-cent-per-mile toll. The comprehensive road pricing policy tolled all of the area's roadways at 7 cents per mile on general lanes and 22 cents per mile on premium lanes.

The HOT lane policy produced substantial net benefits—more than $170 million per year. Travelers gained $105 million in benefits, even after netting out their toll payments, through improved travel times. Gains were both direct (for those who used the HOT lanes) and indirect (for those who benefited from the spillover effects of opening up spare road capacity). All income groups experienced positive welfare changes. The only identifiable losers were previous users of the HOV lanes, who now experienced somewhat longer travel times, and travelers along "non-HOT" corridors. These travelers experienced losses because the policy increased vehicle trips and therefore produced slightly more congestion in the core. Losses were trivial for both of these groups. In addition, the policy raised $65 million annually.

One implication of the research is that compensation of travelers is a much less important issue in a HOT lane context than it is for more global road pricing schemes. In addition, because HOT lanes do not appear to inflict large welfare losses on any identifiable group of travelers (including low-income travelers), HOT lanes appear to be a promising avenue for promoting acceptance of road pricing.

## Road Pricing and Equity in Norway

*Farideh Ramjerdi*

Equity concerns are high on the list of reasons for opposition to road pricing. While some of the popular arguments against road pricing can be dismissed out of hand, equity concerns merit close attention—not just to facilitate implementation of a measure that can improve the efficiency of the transport system but also because equity objectives are important in their own right. A reconciliation of the potential conflict between equity and efficiency can be brought about through the use of at least two policy instruments. First, the recycling of revenues back into the transportation system should be an integral part of the road pricing scheme. Second, an understanding of the valuation of externalities by various socioeconomic groups and regions is essential for evaluating alternative pricing programs.

In forging transport policy, governments ideally have three objectives: raising revenue to provide public goods and services, achieving a desirable income distribution, and controlling externalities. In a perfect world a government has perfect information, can use nondistortionary taxes for revenue-raising and distributive purposes, and has perfect instruments to deal with the transport externalities. In the real world, the evaluation of transport instruments should take into account not only the transport sector but also the rest of the economy and the general tax system.

Norway's urban toll systems have been introduced as financing schemes intended to deal with funding shortfalls that are unfortunately accompanying an increase in road traffic. In 2000 toll revenues contributed about 35% of total funding for transport infrastructure. Since 1986, with the introduction of toll ring schemes in Bergen, Oslo, and Trondheim, and more recently in Stavanger and Kristiansand, there has been a dramatic shift toward toll-financed facilities in urban areas. With low elasticities coupled with a focus on revenue gains, the designs of these systems have exhibited a minor concern for equity and produced limited impacts on congestion levels.

Since the mid-1990s amendments to the national road laws have made it possible to allocate some of the revenues from a toll scheme to public transport investments. A new amendment, approved in June 2002, sanctions the use of a toll scheme for demand management and has opened the door to congestion pricing. Under this amendment the proceeds from a scheme must be used for local road and public transport purposes.

Where are we now in Norway with respect to road pricing? Since the introduction of the toll ring schemes, support for road pricing as part of an integrated package of policy instruments for urban areas has increased. Legal barriers to pricing have diminished. And almost all larger urban areas in Norway now have urban toll rings in place that could be modified to address congestion. Modifications to support congestion pricing might include increases in toll levels, differentiated tolls by time of day, and changes in the location of toll stations. While true congestion pricing will improve efficiency, such improvements may well be accompanied by negative distributive impacts. Revenue recycling can help, but its positive impacts on public opinion will be minimized if there is a lack of transparency in the process of allocating the revenues. Under these conditions, public opinion and political support for the continuation of urban toll and congestion pricing schemes will erode even further.

We therefore argue that policies should be evaluated on both efficiency and equity grounds. Congestion pricing, by its nature, has negative distributive impacts that must be addressed. The design of the integrated policy instruments should take account of the negative distributive impacts by providing the necessary compensation to the losers. Since this alone might not create a political consensus for congestion pricing, further incentives to overcome inequities might be both politically necessary and good public policy.

## Impacts of Pricing on Income Classes

*Douglass Lee*

Vertical equity—the impact of a policy on the distribution of income among income classes—is one of several major components of policy evaluation and a subject that receives a great deal of popular and political attention. Popular comments about vertical equity, however, are often based on a weak understanding of theory and little or no empirical evidence. This is unfortunate, because useful theory and some data are available and allow conclusions to be reached that can improve public decisions.

Though vertical equity is a matter of concern with most policy initiatives, it comes up especially often in discussions of congestion pricing. While existing data do not permit precise conclusions, a close investigation of findings to date and the application of some judgment produce several generalizable results.

First, the distributional impact of peak congestion pricing appears to be mildly regressive, measured against household income, but not regressive enough to stand as an obstacle to peak pricing. Those traveling on urban highways at the peak period in the peak direction are substantially more affluent than the population as a whole, and those who choose to pay the toll are more affluent still.

Second, alternative (existing) financing mechanisms such as fuel excise taxes, sales taxes, and local property taxes are also mildly regressive under typical conditions, so

there is no great urgency to shift away from them on vertical equity grounds. (There are, however, good efficiency and horizontal equity reasons for doing so.)

Third, using toll revenues to reduce general taxes or to provide income transfers based on need is probably the safest way to recycle the revenues generated through pricing schemes. Earmarking revenues for specific purposes can be desirable in closing the loop between payers and beneficiaries but can be dangerous economically and misleading politically. Spending toll revenues to increase highway capacity, subsidize transit, or support the freight rail system may be inefficient if those sectors receive more funds than they can use efficiently—that is, apply in ways that generate positive net benefits. Moreover, since public revenues tend to be fungible, earmarking revenues may simply replace other revenue sources, in whole or in part. With reasonable care, though, recycling the toll revenues should result in a net favorable vertical redistribution.

In short, congestion pricing is probably a progressive policy from the standpoint of redistributional equity, and no worse than mildly regressive.

# Urban Freight Transportation

Mark Griffin, *Southern California Association of Governments*
David Levinson, *University of Minnesota*
Martin Ruesch, *Rapp Trans AG, Switzerland*

## Moving the Goods in Los Angeles

*Mark Griffin*

The six-county region of Southern California represented by the Southern California Association of Governments (SCAG) serves as a crucial node of international and national commercial flows. Commercial movements in and through the region contribute a significant amount of economic activity across the nation. For example, the Southeast region of the United States, inclusive of Miami, recorded slightly more than $87 billion worth of commercial movements with the SCAG region in 2000.

The SCAG region connects with the rest of the nation via a freight infrastructure system that reaches by rail and road to every part of the contiguous states. This connectivity sustains certain levels of economic value nationwide, and the level of activity indicates the magnitude of "value added" attributable to the goods movement infrastructure in Southern California and the nation.

In return for accommodating these international and national commercial flows on its regional freight infrastructure system, the SCAG region receives (and distributes) a lot of freight. This load negatively affects air quality and transportation congestion in the SCAG region and thus diminishes the region's quality of life.

The volumes of freight handled by the region are forecast to double or triple by 2030, depending on the mode of transportation considered. In addition to a local population of 17 million and a regional economic product in excess of $600 billion, several trends in the international logistics industry are working to increase the region's share of freight movements. For example, the effect of "load centering" can be discerned in the increasing market share of Asia-related trade being captured by the ports of Los Angeles and Long Beach relative to other West Coast ports, as well as by the greater proportion (more than double) of Asia trade handled by West Coast ports as a group relative to what would otherwise be expected given their local populations and levels of economic activity. In addition, the practice of "transloading," whereby international goods are repackaged from 40-foot international marine containers into 53-foot domestic containers and trailers, has been identified as a key characteristic in the shaping of regional commercial flows.

The combined effects of load centering and transloading are expected to impose significant new demands on the goods movement infrastructure of Southern California. In light of these developments, SCAG is targeting pricing schemes that are consistent with the development of greater goods movement capacity in the region.

To build needed new capacity, new sources of revenue must be found, and pricing mechanisms of one sort or another are the most likely candidate. The updated 2004 Regional Transportation Plan for the SCAG region, presently out in draft for public comment, identifies user-fee supported revenue bonds as the primary financial strategy for developing greater goods movement capacity. Revenues raised from commercial flows in the region would be used to create new, special-purpose infrastructure capacities. Examples of special-purpose facilities

under consideration include a regional dedicated truckway system and enhanced regional rail capacity. Preliminary financial analyses show that each of these capacity options would be essentially self-supporting with reasonable tolls or other movement charges given certain public debt issuance arrangements, such as tax-exempt revenue bonds, loans made available under the Transportation Infrastructure Finance and Innovation Act federal credit program, and, potentially, tax credit bonds.

With these investments in new goods movement infrastructure facilities, the anticipated increase in average truck delay on the region's transportation system through 2030 could be averted, with future delays held to a reasonable level. Furthermore, the economic effects of these infrastructure investments would benefit the region in terms of employment and revenues.

## Trucks' Value of Time: Implications for Congestion and Weight Limits

*David Levinson*

Minnesota's spring load restriction policy, which places strict limitations on commercial vehicle weights during the spring thaw, has been in effect for more than 50 years. Throughout this time, almost no consideration has been given to the cost that the policy imposes on the freight industry. However, the state has now commissioned a cost–benefit study to examine the policy's necessity. The cost–benefit analysis includes estimates of freight demand and user costs, which are calculated as the difference between total travel time and vehicle miles traveled with and without the policy in effect, with this difference then multiplied by the value of time for commercial vehicle operators in Minnesota. The users' value of time is an essential component, since the policy has numerous impacts that can make freight movement much more time consuming. For example, vehicles complying with the policy must shift seasonal timing of shipments, reduce load size per vehicle, change vehicle types, or change routes, all of which can impose additional costs on commercial vehicle operators.

Researchers have studied the value of time for more than 40 years. Four methods to discern users' value of time are in common use. Estimates of net operating profit fix vehicle and labor costs so that with improved speeds, a vehicle will be able to travel farther in the same span of time and contribute more profit to the company. Cost savings models are based on a reduction of those costs that do not vary with miles of operation. Cost-of-time estimates determine the cost of providing time savings. And finally, the willingness-to-pay approach considers individual choices when respondents are faced with a decision between time savings and other benefits.

Given our specific research question, no estimates, regardless of these approaches, were available from previous studies or data. Absent the necessary revealed preference information, a sample was constructed from several trucking industry sources to conduct a survey. Interviews were conducted by using an adaptive stated preference survey to derive an estimate of the value of time to the nearest dollar.

A tobit model was fit to the data from the interviews to derive the estimate for value of time. A mean of $49.42 was found, with a 95% confidence interval from $40.45 to $58.39. Variation in the distribution of values is largely undetermined with the exception of fleet operation, whether it is a for-hire truck fleet or a private truck fleet.

In addition to deriving estimates for commercial vehicle operators' value of time, which can now inform policy decisions concerning the spring load restriction policy, the analysis helped illuminate the advantages of an adaptive stated preference study in comparison with traditional stated preference studies. The current state of the art in using stated preference methods to evaluate the value of time uses a fee structure in exchange for time savings, in most cases a toll. It has been shown that stated preference methods typically underestimate the true value of time, since the use of a fee structure fails to account for subjects who avoid paying additional fees for a public good that they may believe they pay for in the form of taxes. The fine structure included in the adaptive stated preference study we used for this analysis helped account for these otherwise "missing" subjects and provides a greater estimate for value of time than do previous studies.

## Road Pricing and Urban Freight in Europe: Practices and Developments from the BestUFS Project

*Martin Ruesch*

The BestUFS project (Best Urban Freight Solutions) has run for 4 years, from 2000 through 2003. Besides addressing other urban freight issues, it examines developments in pricing freight movements specific to urban areas throughout Europe over the years. Extensive information on the BestUFS project can be found at www.bestufs.net.

A few of the lessons learned to date are as follows:

- Freight transport's share of the overall transportation sector will increase in the coming years, and this will be true both for urban areas and for interurban trips. Therefore, an understanding of the structure of the freight transport industry, travel patterns, the local framework, the structure of the urban area, and existing access regu-

lations is critical for proper design and implementation of a road pricing scheme.

- The value of time in freight transport is 5 to 10 times higher than for passenger transport. Moreover, the price elasticity for freight movement is low in urban areas; the possibilities for altering transport patterns are limited because of access regulations, shippers' demands, and limited modal alternatives.
- European approaches to road pricing for urban freight are heterogeneous. The United Kingdom, Norway, and Italy lead the field in applying road pricing to freight vehicles. Switzerland (2001), Germany (2004), and Austria (2004) have introduced or are planning distance-based heavy vehicle fees.
- The range of approaches includes single road pricing (e.g., Norway, France), cordon pricing (e.g., Norway, Italy), network pricing (e.g., Germany), and area pricing (e.g., United Kingdom, Switzerland). While each approach has advantages and disadvantages, they tend to be selected on the basis of local conditions and political reality rather than economic theories.
- Financing of infrastructure (e.g., Norway, France, Germany) and demand management (e.g., United Kingdom, Switzerland) are the main objectives.
- Despite urban freight's increasing share of the transportation sector and its importance for the regional economy, road pricing projects continue to focus on passenger transport.
- The London congestion charging project, in place since February 2003, provides an interesting illustration of the impact of political realities on system design. Original plans called for a freight vehicle charge of £15, compared with £5 for cars, which was estimated to represent about 3% to 5% of the daily costs of truck operations. During the consultation process the transport lobby reached a reduction from £15 to £5. Since implementation, the reduction of travel times (by 14%) and the improved reliability (by 30%) are important benefits for urban freight transport. Before implementation the transport sector had great doubts, but since implementation acceptance has improved remarkably.
- The Swiss Heavy Vehicle Fee, in place since January 2001, provides a fine example of successful introduction of distance-based heavy vehicle pricing. Though focused on interurban freight movement, the approach could be adapted to urban areas. The main objectives have been the internalization of external costs and demand management. The fee depends on the distance driven, the vehicle's maximum gross weight, and its emission category. For a 40-ton truck the fee is about €0.40 per kilometer (2001–2004) and will be €0.65 per kilometer (after 2005)—about four to six times higher than the planned fee in Germany. About 70,000 vehicles are affected by the fee daily, and about 57,000 vehicles are equipped with an onboard unit to permit electronic collections. With relatively low capital and operations costs, collection costs are about 4% to 6% of the revenues. Two-thirds of the net revenues are used for financing large-scale public transportation projects, and one-third are directed to the cantons to cover road transport costs. Positive effects identified during the first 2 years of operation include beneficial fleet adaptation, organizational changes, and alternative route and mode choices.

The following is a summary of the main findings:

- Suitable pricing schemes for urban freight transport yield reliability and travel time benefits that exceed the costs.
- Road pricing can improve the efficiency of urban freight movement and foster more sustainable logistics and distribution strategies.
- A demand management approach can generate more benefits for urban freight transport than a financing approach.
- Urban transport policy, not only for passenger but also for freight, ought to address road pricing.
- Urban freight issues should receive greater attention during the development of road pricing strategies and should acknowledge access regulations, emissions categories, vehicle sizes and types, and ultimately differentiated load factors depending on a vehicle's configuration.
- Charges for freight vehicles should be higher than for private cars.
- Early attention to interoperability of selected pricing systems is critical for preventing later discoveries of incompatible approaches.

# The Price Is "Right"
## Perspectives on Finding It

Genevieve Giuliano, *University of Southern California*
Ed Regan, *Wilbur Smith and Associates*
Jim Bourgart, *Parsons Brinckerhoff*
Mark Burris, *Texas A&M University*

### Innovative Financing's Role in Pricing Projects

*Genevieve Giuliano*

Since the passage of the 1956 Interstate Highway Act, highway infrastructure in the United States has been funded, built, and operated almost entirely within the public sector. Infrastructure was funded primarily by fuel and other user fees, and projects were built on a pay-as-you-go basis. This traditional model of highway finance is losing its relevance. Over little more than a decade, an entire array of new funding strategies have emerged. Termed "innovative finance," these strategies seek to leverage public funds by accelerating project construction, facilitating issuance of bonds and other debt instruments, tapping into new sources of revenue (including user charges), or attracting private investment. Perhaps the most extreme form of innovative finance is partial or full private funding and ownership of highway facilities. This presentation investigates the emergence of innovative finance, offers some explanations for its rapid proliferation, and discusses the shifts in risk that innovative finance implies. By using examples of toll road projects drawn mainly from California, I examine various aspects of risk to understand why projects succeed or fail and the lessons that can be drawn for future projects.

The erosion of highway system funding capacity is well recognized. The conventional explanation identifies the declining productivity of the fuel tax, rising costs of construction and of maintaining an aging system, devolution of financial responsibilities to lower levels of government, and general public resistance to tax increases. I argue that there is more to the story: a more general shift in perceptions of the role of government, changes in our understanding of transportation industry structure, mixed evidence of broad economic benefits of highways, increased concern with environmental costs, and lack of consensus on how transportation problems should be addressed.

There are many arguments for innovative finance: projects can be built sooner, public dollars are leveraged, private-sector costs are lower, public–private ventures spread risk, and technology now makes possible user charges and complex revenue-sharing agreements. Despite these advantages, most innovative finance projects to date have been various forms of fund advancements and more flexible financing arrangements. Relatively few new highway projects include significant private-sector participation.

My assessment of two groups of projects—the Assembly Bill 680 toll road projects in California and four new suburban toll roads—focuses on the various types of risk such projects face. I conclude that successful projects require uniquely favorable conditions; political acceptance and the sustained support of public partners are critical. Fully private facilities are generally not economically viable because of very long payback periods and uncertain user revenue streams. Moreover, the public sector retains the residual risk, even in the case of fully private projects.

## Experiences with Active Projects: Interstate 10

*Ed Regan*

As congestion pricing moves from theory to practice, new opportunities for providing higher-quality transportation through the use of managed lanes and, potentially, bus rapid transit are emerging. Two prime examples of managed lane facilities are (*a*) the new Interstate 10 managed lanes project in Houston, which is being implemented as part of a major Katy Freeway improvement program and which provides an excellent illustration of the opportunities offered by blending the high-occupancy toll (HOT) lane concept with bus rapid transit, and (*b*) the existing Interstate 15 managed lanes project in San Diego, soon to be more than doubled in size.

The Interstate 10 expansion program involves expansion of an existing seven-lane highway [six general-purpose and one high-occupancy vehicle (HOV) lane] to eight general-purpose and four value-priced managed lanes. The managed lanes are being financed by the Harris County Toll Road Authority. Under a multiagency agreement, transit buses will be able to use the managed lanes toll free, and the toll agency has committed to charge sufficiently high prices to ensure free-flowing operations in the managed lanes even during peak periods.

As a result, the Interstate 10 managed lane solution essentially creates a two-directional, free-flowing "virtual" busway, shared with (and paid for by) passenger car motorists willing to pay a toll to obtain the same time savings advantages afforded to the buses. In this way, HOT lanes and bus rapid transit will be able to work better together, a "win-win" scenario for both the highway side and the transit side. Twinning these features has the potential to result in an integrated high-quality transportation solution that can manage demand while generating revenue and providing a built-in incentive for increased use of transit.

Another managed lane application meriting attention is the successful Interstate 15 project in San Diego, which stands as the world's first and only use of fully dynamic variable pricing. Single-occupant vehicles are allowed to "buy in" to previously constructed HOV lanes, and one noteworthy feature of this project is the extremely positive results generated from extensive public opinion polling. The surveys have shown strong support for the variable pricing approach, with overwhelming approval registered by both users and nonusers of lanes as well as carpoolers and transit patrons. In fact, the most frequent response to a question about the single most effective way to reduce congestion on other portions of Interstate 15 was to extend the tolled express lanes, which showed consistently more support than simply adding toll-free regular lanes.

## Interstate 680 and Other California Projects

*Jim Bourgart*

By charging single-occupant vehicles for the opportunity to use freer-flowing HOV lanes, HOT lanes offer a number of benefits: more efficient use of HOV lane and freeway capacity, revenue generation to support transportation improvements, and the opportunity to sustain public support for existence of HOV lanes at all.

A prime example of the HOT lane concept is the planned 14-mile Interstate 680, which emerged as a strong candidate because of the following characteristics: (*a*) sufficient distance with heavy congestion and strongly directional commute traffic, (*b*) relatively few interim on/off users given the concentration of Silicon Valley jobs at the south end and residences at the north end, (*c*) sufficient right-of-way and the preexisting plan to include HOV lanes on the facility, and (*d*) real financial needs. The anticipated alignment will include three general-purpose lanes in each direction and an HOV-HOT lane in each direction as well.

The tolls will be adjusted up or down periodically on the basis of demand, which will ensure that the combined HOV-HOT lane does not become congested. The specific approach for the fee structure is being developed through use of an optimization model that interacts with the regional transportation model and solves for prices that meet efficiency, revenue maximization, throughput, and other desired goals. Because the key to value pricing is motorists' desire to trade off time versus cost, one of the keys to making an accurate variable pricing forecast is the distribution of users' value of time. At first, we anticipate a peak toll rate of between $3 and $4 for the full 14-mile distance. There will also be an off-peak price and a "shoulder" period price. At this level, tolls in both directions would generate between $6.3 million and $14.7 million in revenues in 2006 and between $12.3 million and $31.9 million in 2025. Revenues will be used to pay for HOT lane operations, improved bus service on the I-680 corridor, and capital improvements to the I-680 corridor.

One of the most interesting parts of the analysis was the impact of the definition of "HOV" (two versus three or more vehicle occupants) and the availability of intermediate access into the HOT lane. Not surprisingly, an HOV-3 policy generated significantly more revenue. The following table shows the anticipated 20-year net present value of operating incomes at a 4% discount

rate under various scenarios in 2002 (U.S. dollars in millions):

| | *HOV2+* | *HOV3+* |
|---|---|---|
| No intermediate access | 142 | 207 |
| With intermediate access | 83 | 228 |

Consistent with its design as a demonstration project, the I-680 HOT lane approach has the capacity to offer answers to some of the questions that continue to accompany the value pricing concept. Will drivers see the HOT lane as worthwhile? How much will they be willing to pay? How many vehicles and people can move through this corridor, and at what speeds? Can smooth traffic flow be maintained? How much revenue will be generated? And perhaps most difficult, will the system be perceived as fair?

The project also presents its designers with some real operational challenges and the opportunity to investigate such things as the effectiveness of enforcement policies, the impacts on HOVs, and the impact of constraining or increasing access to the HOV-HOT lane. Other pricing studies in the Bay Area have generated some helpful lessons; those studies include the I-880 commercial vehicle initiative, the Sonoma–Marin US-101 HOT Lanes, Santa Cruz Highway 1, and the Bay Bridge Congestion Pricing Project.

## Price Demand Elasticities and Usage of Houston's HOT Lanes

*Mark Burris*

The HOV lanes in Houston were highly successful—so successful, in fact, that two of them (Katy and Northwest) exceeded capacity during the morning peak period when they were open to all vehicles with two or more occupants. However, after raising the occupancy restrictions to three or more persons during the peak periods, there was significant excess capacity. Therefore, to better utilize the lanes, Houston METRO and the Texas Department of Transportation implemented a value pricing project named QuickRide.

QuickRide is an innovative project designed to use the capacity of the HOV lanes on the Katy and Northwest freeways more effectively. Under this project, two-person carpools can pay $2.00 to use the HOV lanes during the peak period, even though the lanes are normally restricted to vehicles with three or more occupants. This form of HOV lane is typically termed a HOT lane and can be an effective travel demand management and congestion mitigation tool.

This method of managing demand has worked well since its implementation in 1998, with steady increases in usage and enrollment. However, with reconstruction of the Katy Freeway corridor under way, the Katy HOV lane could be an even more valuable asset in managing traffic, both peak and off peak. In addition, more HOV lanes in the Houston area are nearing capacity during peak periods. Therefore, additional efforts are under way to increase the QuickRide project's effectiveness in utilizing the HOT lanes. This could include increasing the hours of QuickRide operation, dynamic pricing of the HOT lanes on the basis of congestion, variable pricing of the lanes on the basis of time of day, and even allowing single-occupant vehicles on the lanes for a higher toll than those paid by two-person HOVs.

One important tool for use in predicting driver response to these potential toll changes is the price elasticity of demand for the HOV lane. For 1 month, April 2003, the price of QuickRide was reduced to $1 per trip. The resulting price elasticities of demand ranged from –0.11 to –0.26, with an average of –0.19. These results indicated an inelastic response to changes in the toll.

A survey of QuickRide enrollees and former enrollees was also conducted in spring 2003. The survey results supported the previous elasticity results. The primary issue limiting QuickRide use appears to be one of convenience rather than cost. Both current and former participants cited the inconveniences of carpooling as the greatest deterrent to QuickRide use, while 73.4% of participants reported that the toll had little or no impact on their decision to use QuickRide. A survey of corridor travelers who do not use QuickRide is scheduled for fall 2003; we anticipate that this survey will provide additional insight into driver behavior to optimize the pricing structure for the HOT lanes.

# Factoring Pricing into the Planning Process

Yvonne Need, *AVV Transport Research Center, Netherlands*
Robert Dunphy, *Urban Land Institute*

## Public Acceptance of Pricing Schemes for the Netherlands

*Yvonne Need*

The Netherlands' experience with road pricing dates back to 1995, when a coalition of political leaders formally accepted pricing as a means to manage traffic and finance infrastructure. However, in the following years the policy received significant scrutiny from Parliament and opposition from the Dutch motoring lobby. By 2001, transportation officials were focusing on a simple charge-per-kilometer approach, because they had found that actual congestion-based charges suffered from a troubling lack of public acceptance.

Surveys found little public acceptance for pricing, or feigned acceptance. The surveys also identified a significant distrust of government, which primarily took the form of suspicion that road pricing is meant not to prevent congestion but rather to collect more money for the state. A companion concern was that prices would go up any time the government felt the need for more revenue.

The surveys also revealed a remarkable lack of awareness of the nature of congestion. Most respondents said that the biggest problem on the roads was the behavior of other road users; only 32% of respondents named congestion itself as a problem. Congestion was also seen as a simple fact of life and as something that would be impervious to any policy initiatives seeking to influence it. Understandably, most respondents viewed congestion as a societal problem produced by others, with individuals stating that they themselves do not drive more than necessary.

The public also expressed concerns about fairness, and particularly the fear that pricing will lead to a system in which the rich will be able to drive as much as they please while the poor won't be able to afford to drive anymore. Concerns about fairness also centered on a fear of fraud, such that honest people would end up shouldering most of the financial burden. Finally, a small but passionate majority voiced anxiety about pricing's implications for personal privacy.

Given the public's concerns about congestion pricing, I would like to put forward a series of recommendations for advancing the political viability of congestion pricing. The recommendations include a commitment to use strong communications as the pillar of the introduction strategy, an effort to discuss and demonstrate anticipated effects at the individual and societal levels, and assurance that all claims can be substantiated. It is also important to develop a good marketing strategy and state the program's goals clearly. From a technical perspective, planners should avoid starting with a low price that is sure to be raised later, and they should avoid funding systems that force citizens to pay for the costs of introducing the program. It is also worthwhile to identify groups that will gain and groups that will lose out so that any equity implications of the pricing program can be directly addressed. Finally, in recognition of the concerns raised by the small but vocal minority who are especially concerned about privacy, it is important for the program design to include safeguards that guarantee the privacy of system users.

## Pricing Traffic, Pacing Growth

*Robert Dunphy*

New developments in transportation pricing and continued shortfalls in public coffers indicate that the time is right for a different approach to funding transportation. Significantly, expanded use of road pricing promises also to help pull new housing inward, in contrast to the current system under which people often accept longer commuting distances in an attempt to find lower-priced housing. Several new pricing strategies have the potential to exert an especially powerful influence on land use patterns.

The first is a street service fee, which would shift the lion's share of highway finance from the gasoline tax to a street service fee paid by the month, similar to fees for cable TV or the Internet. This approach would result in an immediate drop in the price of gasoline, simplify the adjustment of user charges, and protect transit revenues. A monthly utility or telecommunications fee is already familiar to most Americans and thus would not represent a wholly foreign concept. It could also make car taxes more palatable by spreading them over a year rather than imposing them in one or two payments per year, as is typical for most car licensing fees. A simple fee would be based on annual mileage estimates adjusted regularly for actual use. Technology could allow the charging of higher rates on congested facilities.

The second is an honest pricing approach. The growing acceptance of charging solo drivers for an uncongested commute in HOT lanes creates a new opportunity to fund radial highways needed to accommodate suburban growth. New radial roads needed to serve suburban expansion would all be priced. Rather than choosing the largest house for which a buyer qualifies and worrying about the traffic later, a "drive to qualify" decision would require weighing the savings in house payments against potentially significant marginal driving costs. Asking home buyers to pay the cost of sprawl could help reverse the middle-age spread of most regions and create a sizable new funding source. It would also protect residents of new developments from a future of being stuck in traffic.

Four recent experiences in pricing demonstrate the growing acceptance of a price-based approach to financing infrastructure and managing demand; they also provide good test cases to help us understand the land use implications of various pricing approaches. Land use results from the following experiments can be expected to generate informative results in the coming years. At one end of the spectrum, HOT lane demonstration projects are the "light beer" of pricing even though they require considerable efforts for successful implementation. At the other end, London's congestion charging scheme represents a "deep pricing" approach and offers a new model for many cities struggling to deal with the effects of car traffic.

- Unprecedented improvements in London's traffic brought about by London's program have rewarded Mayor Ken Livingstone with strong public support.
- A "London-like" proposal for New York could result in similar levels of congestion relief, as well as an infusion of between $7 billion and $19 billion for badly needed transportation investments.
- In Minnesota, which has studied pricing since 1994, the stars are aligned to create the state's first HOT lane conversion on Interstate 394, reinforced by the need for money.
- The Seattle, Washington, region, whose 205-mile network of carpool lanes is one of the nation's largest, is about to proceed with its first HOT lane and has studied an extensive pricing system for a regional network of 131 miles on seven major highways.

# Responses to Findings
## The Future of Pricing

Steve Heminger, *Metropolitan Transportation Commission and Conference Chair, Facilitator*
Emil Frankel, *U.S. Department of Transportation*
Marcel Rommerts, *European Commission*
Anne Canby, *Surface Transportation Policy Project*
Dan Beal, *Automobile Club of Southern California*

The symposium closed with a roundtable discussion facilitated by Steve Heminger, conference chair.

In response to a question on the toll and pricing provisions included in the U.S. administration's proposed bill to reauthorize the federal highway and transit programs, Emil Frankel noted that two factors—the difficulty of expanding capacity through new infrastructure and a shortage of capital—have coalesced to create sustained interest in road pricing. As a result, the administration's bill calls for a gradual "mainstreaming" of the prior toll provisions. Mr. Frankel also noted that the legislation is permissive, not directive, in allowing states and local governments the flexibility to pursue pricing as standard practice rather than through a pilot project. The bill stopped short of repealing the ban on tolls on the Interstate system, however, in recognition that the nation has not fully entered the road pricing era, though it is close to doing so.

The administration joins with others in the transportation community in its concern for the fuel tax's long-term sustainability as the principal revenue source for funding the nation's surface transportation system. While the administration chose not to include a directive for a blue ribbon commission to examine alternatives to the fuel tax in its bill, research into user-based mechanisms is well under way; the administration expects that the nation will be in a good position to vet a range of alternatives by the time of the next surface transportation reauthorization. Mr. Frankel added that technological advances are key to broadening the range of available policy choices and indicating which policies are most feasible and desirable.

Audience members posed several questions to Mr. Frankel. A speaker from Minnesota noted the criticality of the federal value pricing pilot to that state's decision to undertake a pricing experiment and expressed concern that "mainstreaming" value pricing through elimination of the value pricing pilot program could halt further progress in the area. Another speaker questioned the administration's decision to delete the directive for a blue ribbon commission to consider alternatives to the fuel tax. Mr. Frankel noted that this is a pivotal time, in that the "push" of resource constraints is coinciding with the "pull" of new technologies to spur greater attention to pricing systems. He expressed confidence that pricing, if properly explained to the public, would garner widespread support.

To provide a European perspective, Marcel Rommerts explained that while Europe already has many interurban toll roads, ample opportunity exists for refinements, especially in the area of truck-borne freight. Mr. Rommerts indicated that the increased use of pricing for trucks is expected to level the playing field among the various transport modes and classes of vehicles and, of course, to raise revenue. Another key lesson to date is that in contrast to the interurban point-to-point model, the cordon-based approach that London has successfully implemented is emerging as a promising strategy. He noted that more experiments in European cities are likely in the coming years but that a political champion for the strategy is essential; in London, Ken Livingstone's persistence and enthusiasm for the cordon system were critical to the ultimate implementation of the pricing program.

Mr. Heminger asked Anne Canby whether a consensus was starting to emerge among those who have registered concern over pricing's potential implications for equity and those who have favored pricing for its environmental benefits. Ms. Canby said that the tensions surrounding road pricing underscore the need for a broad tent. She added, however, that different groups' objectives may be more consistent than might first appear; for example, the environmental community's support will depend, in large part, on the dedication of revenues to strategies designed to broaden and improve the public's travel choices. Groups such as the Surface Transportation Policy Project also call for full consideration of pricing's widespread impacts; for example, she added, officials in Delaware fully integrate the state transportation funding and investment system into an overall transportation strategy. Both of these conditions are clearly consistent, with close attention to the equity implications of any pricing project.

Ms. Canby went on to say that equity remains a pressing issue, and given that the cost of transportation is a proportionally greater burden on those with lower incomes, any pricing scheme ought to include strategies for offsetting the economic impacts on poorer travelers. Political support can be mustered only through absolute transparency in the decision-making process and early involvement of the grassroots community. In general, decisions should be made at the level of government closest to the impacts of the scheme itself; in urban areas, for example, the focus probably should be on the metropolitan planning organization rather than the state department of transportation.

Finally, representing the automobile users of the United States, Dan Beal stated that the American Automobile Associaton is well informed by its more than 40 million members and its own research of the many transportation challenges facing mobility in the United States. The association is well aware that the current system for funding U.S. highways will face severe challenges in the years ahead. Citing a distinction made in the past by Ken Orski of the Urban Mobility Corporation, Mr. Beal explained that while "value pricing," which offers drivers an option to pay for a superior level of service, may be acceptable to the association, more skepticism surrounds full-fledged congestion pricing, in which pricing is used to manage demand even in the absence of any benefit to those who pay. Mr. Beal added that the association's support of the State Route 91 and Interstate 15 express lanes underscored this perspective. One remarkable outcome of the SR-91 experiment, he added, is that the original allegation that the express lanes would turn into "Lexus lanes" was disproved; in fact, the benefits have been widely distributed. He reiterated that this outcome—the creation of an improved level of service for a large number of drivers—was essential to the association's support of any pricing project. Mr. Beal also noted that proponents of pricing must make a convincing case of its merits and not simply seek to impose it on the public through an assumption of what is best for American drivers.

# Resource Papers

RESOURCE PAPER

# Then and Now
## The Evolution of Congestion Pricing in Transportation and Where We Stand Today

Martin Wachs, *Institute of Transportation Studies, University of California, Berkeley*

The proposition that roads should be priced in part to manage congestion by influencing traffic flows is not a new one. References to the concept have appeared in the scholarly literature for at least 83 years. But, like many good ideas in the realm of public policy, it has taken quite a while to catch on. The views of scholars do sometimes influence public policy, but only after being shaped by policy makers and opinion leaders do they ultimately make their influence felt. The question we are here to explore is whether road pricing has finally entered or is about to enter the mainstream of transportation policy. We will do this at an international conference because the history of transport policy, the nature of road pricing, and the response to experiments with congestion pricing are sensitive to the contexts in which they have been discussed and attempted, so there is much to learn through comparison. Over the coming few days we will hopefully learn from and teach one another by analyzing how history and current experiments in many places interact with and depend on their physical, social, economic, and political environments.

I believe our deliberations and case studies will convince us that road pricing is not quite yet within the mainstream of transportation policy options but that more progress has been made in that direction in the last decade than had been made in the preceding 70 years. Road pricing is at a critical juncture in North America today. It remains fragile, yet it is poised to be adopted on a much broader scale than would have seemed feasible only a decade ago. There is still a great deal of skepticism and some overt opposition on the part of policy makers and elected officials, but the concept has survived and has been tested in a number of applications despite widespread doubts. A decade ago I thought the odds were against achieving road pricing on a large scale, but today I am far more optimistic, and the reasons are the organizing theme for my presentation.

## Evolution of Arguments for Congestion Pricing in the United States

Congestion pricing was, to my knowledge, first suggested by economist A. C. Pigou in 1920. His words are reproduced in the accompanying Box 1. Pigou's concept was amplified by economist Frank Knight in 1924, in a passage also reproduced in the box. The language used by these two distinguished economists is not terribly different from that used in later years by such well-known advocates for congestion pricing as Nobel laureate William Vickrey in the 1960s and 1970s.

It would be a mistake to interpret these early suggestions as a quaint historical footnote that was of limited relevance to the political debates about transportation that were current when they were written. In the early 1920s, in both the United States and Europe, automobile ownership and the use of motor trucks were growing at more rapid rates than at any time before or since. While the provision of roads had for many centuries been a responsibility of local communities, the dramatic growth of automobile and truck travel in the early 1920s was causing much greater traffic between communities, and the emphasis in transport policy making

BOX 1
## Pigou and Knight on Congestion Pricing

PIGOU ON CONGESTION PRICING IN 1920

Suppose there are two roads, ABD and ACD, both leading from A to D. If left to itself, traffic would be so distributed that the trouble involved in driving a "representative" cart along each of the two roads would be equal. But, in some circumstances, it would be possible, by shifting a few carts from route B to route C, greatly to lessen the trouble of driving those still left on B, while only slightly increasing the trouble of driving along C. In these circumstances a rightly chosen measure of differential taxation against road B would create an "artificial" situation superior to the "natural" one. But the measure of differentiation must be rightly chosen.

Source: Pigou 1920 (see especially p. 194).

KNIGHT ELABORATING ON PIGOU IN 1924

Suppose that between two points there are two highways, one of which is broad enough to accommodate without crowding all the traffic which may care to use it, but it is poorly graded and surfaced, while the other is a much better quality road but narrow and quite limited in capacity. If a large number of trucks operate between the two termini and are free to choose either of the two routes, they will tend to distribute themselves between the roads in such proportions that the cost per unit of transportation, or effective result per unit of investment, will be the same for every truck on both routes.

As more trucks use the narrower and better road, congestion develops, until at a certain point it becomes equally profitable to use the broader but poorer highway. The congestion and interference resulting from the addition of any particular truck to the stream of traffic on the narrow but good road affect in the same way the cost and output of all the trucks using that road.

It is evident that if, after equilibrium is established, a few trucks should be arbitrarily transferred to the broad road, the reduction in cost, or increase in output, to those remaining on the narrow road would be a clear gain to the traffic as a whole. The trucks so transferred would incur no loss, for any one of them on the narrow road is a marginal truck, subject to the same relation between cost and output as any truck using the broad road. Yet, whenever there is a difference in the cost, to an additional truck, of using the two roads, the driver of any truck has an incentive to use the narrow road, until the advantage is reduced to zero for all the trucks.

Source: Knight 1924.

was on providing a fundamental road network to get farmers "out of the mud" and to enable citizens to drive over longer distances between towns. In Europe, responsibility for building new main roads most often fell to national governments, while in the United States responsibility for providing mile after mile of new highways fell primarily to the states. Many states found themselves spending a major proportion of their general tax revenues on road building, yet congestion was worsening because of rapid growth in travel rather than being eliminated by these projects.

At exactly the time that Pigou and Knight were writing, Oregon had set the tone before 1920 by adopting a motor fuel tax that was hypothecated or earmarked to be spent only on road construction and maintenance. Dozens of states adopted such taxes in the 1920s. Interestingly, texts of the debates held by state legislatures at that time indicate that most of them consciously adopted the fuel tax as a second-best approach. They believed that tolls were inherently the most appropriate way to raise money for roads, since the beneficiaries would pay at the time and place of use, but tolls were expensive and awkward to collect. In addition to absorbing a fifth to a quarter of their proceeds in costs of administration, tollbooths themselves created travel delays and traffic safety hazards. Motor fuel taxes were seen as imperfect substitutes, but they had the advantage that they were easily administered and that the costs of administering them were closer to 3% or 4% of their proceeds. Hypothecated motor fuel taxes were popular among truckers, automobile clubs, newspapers, and politicians, and they played a central role in providing the basic road infrastructure that was at that time so desperately needed (Brown 2001).

Over many decades we became so accustomed to paying earmarked fuel taxes, including those levied since 1932 by the federal government, that we gradually forgot there had ever been discussions of tolls as a superior means of financing transport systems. As road capacity expanded, we also failed to note that discussion of congestion tolls was highly relevant to public debates about how to manage congestion on roads and simultaneously to raise revenue needed to build roads as part of that management program. Most Americans, unfortunately, think that where tolls are not charged their roads are "free," while of course they are paying for their travel through a variety of other taxes and fees that they may not even know of.

In Europe, tolls, fuel taxes, and hypothecation were also debated at just about the same time that Pigou and Knight were writing. Hypothecation was much more rarely adopted in Europe than in the United States. In most instances fuel taxes were merged with government revenues from other sources while appropriations for roads were made from general government funds. Nevertheless, fuel taxes emerged as sources of revenue for governments that, in Europe as in North America, were building thousands of miles of new roads in response to the growth of automobile travel at the time.

Over many decades growth in travel continued to create congestion, but through motor fuel taxes and tolls levied on some major long-distance highways and many bridges, growth in travel also produced growth in revenue that was used to build and maintain the transport system. It was not until the 1960s that this method of infrastructure finance and management began to show signs of deterioration.

Population and economic growth after World War II led to urban congestion. In response, urban and suburban highways and freeways were constructed to alleviate overcrowded city centers.

Gradually, the earlier solutions came to be seen as inadequate. The costs of new roads grew as higher design standards were used; more property was taken; and communities demanded mitigation measures to address increasingly controversial losses of homes, businesses, and recreational facilities. Gradually, too, citizens and politicians became increasingly reluctant to raise the rate of motor fuel taxation, and highway budgets became more limited as inflation reduced the real value of tax collections (Taylor 1995). In addition, many jurisdictions believed that it was appropriate to spend highway user fees for nonhighway purposes. In some places, it was seen as reasonable and proper to use motor fuel tax revenues to support public expenditures on maintaining and upgrading public transit systems as they gradually were transferred from private to public ownership. In other jurisdictions, motor fuel tax revenues were used for nontransportation purposes. In Texas, for example, one-fourth of the proceeds of motor fuel taxes are earmarked for expenditures on public education. However well justified these policies were seen to be by many citizens, they were seen by others as a "diversion" of what rightfully should be spent on highway programs (Roth 2003). And, whether or not fuel taxes rightfully should be reserved for highway programs, highway spending in real dollars has declined in relation to growth in population and travel for several decades.

The effects of these trends on highway programs have been exacerbated by the gradual increase in fleet-average fuel economy. While new cars typically traveled about 12 miles to the gallon in 1950, today average new car fuel efficiency is well over 20 miles per gallon, and even sport-utility vehicles today are more economical of fuel than were standard sedans three decades earlier (Wachs 2003). In the United States the federal gasoline tax now stands at 18.4 cents per gallon, and state motor fuel taxes range from a low of 7.5 cents per gallon in Georgia to a high of 29 cents per gallon in Rhode Island. If the fuel tax had risen sufficiently since 1957 to keep pace with the Consumer Price Index, the average tax per gallon among the 50 states would today be 9.7 cents per gallon higher than it is. If measured in revenue per vehicle mile of driving, the effects of improved fuel economy make this comparison even more dramatic. In Virginia, for example, the combination of state and federal fuel taxation today produces revenue that is 42.4% below the proceeds per mile of driving in 1957. On the one hand, the method of raising revenue for transportation projects does not meet rising costs, and so the condition of the system deteriorates and the capacity of the system expands much more slowly than travel volumes. For example, between 1980 and 1999 vehicle miles of travel on U.S roadways grew by 76 percent, while lane miles increased by only 3 percent (Wachs 2002).

On the other hand, the method of collecting revenue does not itself induce more efficient use of the system, as many believe congestion pricing would do. It was therefore quite logical that as the fuel tax gradually produced less revenue in relation to travel, many started to renew the call for congestion pricing. Proponents like William Vickrey took cognizance of its complementary properties. It produces needed revenue while encouraging more efficient use of existing road capacity by inducing some to shift their travel to off-peak times, to other modes, and to less crowded roads. These properties are noted so persuasively by Vickrey in his own writings that I have reproduced some of his statements here rather than paraphrasing them (see Box 2).

It was not at all coincidental that calls for increased application of congestion pricing arose in the 1960s and 1970s and accelerated in the 1980s and 1990s as highway programs were affected simultaneously by congestion resulting from growth in economic activity and declining revenue from the motor fuel taxes in relation to travel. While Singapore had adopted congestion pricing with some success, it remained largely untested in the United States and Europe, a reflection of political realities that always make it difficult to shift direction in more than incremental ways in democratic societies.

Despite growing attention to road pricing by scholars and sophisticated policy wonks, it was difficult to find many practical politicians who advocated pricing. Altshuler (1965) had noted several decades ago that policies are adopted when they spread benefits broadly and concentrate costs narrowly, while those that spread costs more widely, like road pricing, are far more diffi-

BOX 2
**William Vickrey on Congestion Pricing**

There are probably few areas in modern economic society where conditions are as far from ideal as in the congested traffic and transportation facilities of our great modern metropolitan conurbations. This is equally true in the short run, in terms of making the best use of the facilities we have and, in the longer run, in terms of the appropriateness of the facilities for current and projected traffic needs.

This relative inefficiency can be attributed in large measure to the fact that the individual user, faced with alternative ways of achieving his objectives, does not, under existing conditions, receive any obvious indication of the costs which his choice will impose on others, whether by impairment of the quality of service or by the cost of expanding the facilities to the point where this impairment is prevented.

To begin with it is perhaps worth observing that sometimes a facility becomes worthless precisely because it is free. For example, where a high-speed or short-cut facility of limited capacity has as an alternative a more circuitous or slower route with ample capacity, free operation may mean that a queue builds up during heavy demand periods at the access to the faster facility until the time required for queuing and transit is equal to the transit time by the circuitous route; under these circumstances no-one is able to make the trip any faster than if the faster route did not exist. Enlargement of the faster route may be a complete waste of money unless the route is enlarged sufficiently to take care of all traffic that might offer.

Source: Vickrey 1967.

cult to enact. In addition, in the American political system, proposals must survive many rounds of review and discussion by diverse interest groups before numerous legislative committees and often at many levels of government. To be enacted, a proposal must be supported in most of these settings. Those that are hailed by some and condemned by others most often fade away in our consensus-directed democracy (Wachs 1994). While congestion pricing had its outspoken advocates, I wrote in the early 1990s that it also had many detractors, and the latter were often more influential. The advocates were professors and environmentalists with limited political influence, while the detractors were more numerous and more potent political adversaries, including automobile clubs, trucking associations, and chambers of commerce. Under such circumstances, it was difficult to anticipate, only one decade ago, the adoption of road pricing in the near future in democracies such as the United States.

## THE *CURBING GRIDLOCK* STUDY

Under the circumstances I have outlined above, roughly a decade ago the Transportation Research Board and the Commission on Behavioral and Social Sciences and Education of the National Research Council (NRC) agreed to conduct a joint study that would

- Assess and synthesize available research and experience on congestion pricing,
- Commission papers on critical issues raised by congestion pricing to be presented at a national symposium, and
- Develop recommendations on the potential role of market pricing principles as a tool for congestion management, guidelines for the assessment of the impacts of congestion pricing experiments, and fruitful areas for further research, demonstration, or experimentation. (Transportation Research Board and Commission on Behavioral and Social Sciences and Education 1994, v)

A committee of 15 experts assisted by capable NRC staff members and eight nonvoting liaison representatives from interested government agencies and industry associations met and deliberated over a period of nearly 3 years. The report of this committee consists of two volumes, one in which its findings and recommendations are summarized and a second containing the papers that were commissioned and presented at the national symposium. The report provides a good summary of the state of congestion pricing a decade ago, and thus it is an important baseline that we may use at this symposium to measure accomplishments and changes in attitudes and expectations over the past decade. The findings and recommendations contained in *Curbing Gridlock* are summarized in Boxes 3 and 4, respectively.

I would characterize the outcomes of *Curbing Gridlock* as guardedly optimistic with respect to the potential of congestion pricing to become a substantial element of the transport policy agenda in the United States. Like many commissions and committees created in the public policy arena, and consistent with the mandates of the National Academies, this study committee avoided enthusiastic advocacy. It attempted to present a balanced view based on the availability of partial evi-

BOX 3
**Findings from *Curbing Gridlock***

- Congestion pricing would cause some motorists to change their behavior.
- Congestion pricing would result in a net benefit to society.
- Congestion pricing is technically feasible.
- Institutional issues are complex but can be resolved.
- All income groups can come out ahead given an appropriate distribution of revenues.
- Some motorists would lose.
- Congestion pricing would reduce air pollution and save energy.
- The political feasibility of congestion pricing is uncertain.
- Evaluation of early projects is crucial.
- An incremental approach is appropriate.

Source: Transportation Research Board and Commission on Behavioral and Social Sciences and Education 1994, Vol. 1, pp. 4–9.

dence. It indicated that the potential of road pricing to contribute to the lessening of congestion in urban areas was significant but largely untested at the time. It concentrated on urging further study, research, experimentation, and evaluation of field experiments and on recommending governmental programs that would make them possible. It concluded that most evidence suggested that road pricing could make a significant contribution to the alleviation of worsening traffic congestion. Yet the report simultaneously acknowledged great uncertainty with regard to distributional issues: Could such programs be carried out without harming lower-income travelers, women, and members of minority groups? The report also acknowledged that as a community of interest we have less insight than we would like into the economic development and environmental outcomes of road pricing as well as the implications for land use and urban form.

It is interesting to note that the majority of the recommendations from *Curbing Gridlock* have not been implemented, although some important ones have been. Consistent with the recommendations, when the federal government reauthorized the surface transportation program by enacting the Transportation Equity Act for the 21st Century in 1997, the congestion pricing demonstration program was included and renamed "value pricing" to reflect a larger scope including, for example, high-occupancy toll (HOT) lanes. The program, however, is not slated for inclusion in the Bush administration's current proposal for reauthorization in 2003 or 2004. In addition, a variety of approaches have been considered to remove the prohibition on the charging of tolls on the Interstate system, and this restriction no longer seems to be binding in the long term. And, consistent with the recommendations of the study, Congress has acted to treat employer subsidies of public transit and employee parking more equally than was the case previously. However, the report's suggestions that Congress provide incentives to fund major programs in metropolitan areas, fund extensive evaluations of experimental programs, and provide matching development funds to local governments have not been enacted. Most of the recommendations aimed at state and local governments and those that specifically enumerated research opportunities have not been undertaken. Despite this, as will be shown in the following sections, there have been important changes in attitudes toward congestion pricing, and it is reasonable to say that public policy makers appears more receptive to the concept than was the case at the time the study was completed.

## RECENT PRICING TRENDS IN THE UNITED STATES

### Facility Pricing in the United States Versus Area Pricing in Europe

Although road pricing in the United States remains controversial and vulnerable to organized opposition, it has actually advanced dramatically since the publication of *Curbing Gridlock*, probably to a greater extent than had been envisioned when the report was published. As more fully described in the companion resource paper by two European authors, the complexion of pricing in the United States is noticeably different from that in Europe. Most of the highly publicized applications of road pricing in Europe are area pricing schemes, similar to the original application of pricing in Singapore, and involve cordons about central city locations. Fees are paid, as in London or Trondheim, to cross the cordon in order to enter a central congested area during peak periods. In America, by contrast, there are few applications of area pricing schemes. Instead, most applications are located on highway facilities, where fees are required to enter certain lanes during periods of congestion.

In part, the prominent difference between the growth of area schemes elsewhere and facility-based schemes in

BOX 4
**Recommendations from *CURBING GRIDLOCK***

FEDERAL GOVERNMENT

Congress should extend the pilot program when the Intermodal Surface Transportation Efficiency Act (ISTEA) is reauthorized in 1997.

Public officials (state, local, or regional depending on who has authority) should be given discretion regarding the use of revenues collected by congestion pricing pilot projects.

Congress should allow congestion pricing on urban Interstates or other federal-aid routes if called for in state implementation plans (as required by the 1990 Clean Air Act Amendments) or if local or state authorities can demonstrate the need to manage congestion on these facilities through pricing.

The federal government should provide additional incentives to encourage pricing on more than just single facilities by giving substantial grants or additional housing, transit, or community development funds to any metropolitan area with significant congestion that is willing to experiment with broader pricing strategies, for example, a regional parking management program.

In cases where high-occupancy-vehicle (HOV) lanes on federal-aid facilities have clearly failed to induce ridesharing, or in cases where local officials can show that adding congestion pricing on existing HOV lanes would not undermine the region's HOV strategy, experiments should be allowed that would convert underused HOV lanes to tolled lanes while allowing HOV users to continue to travel at no charge.

Because of the unique opportunities offered by congestion pricing projects to learn about behavioral responses to variable pricing and how they affect travel demand, the federal government should bear the bulk of the cost of extensive evaluations.

Matching project development grants should be made available to local governments, states, toll authorities, and metropolitan planning organizations funded out of the congestion pricing pilot program section of ISTEA.

Federal law should treat the tax-exempt status of parking and transit subsidies equally and should require employers who provide parking subsidies to give employees the option of taking this subsidy in the form of cash.

STATE AND LOCAL GOVERNMENTS

State and local governments should adopt statutes similar to the California law requiring "cashing out" employee parking.

RESEARCH PRIORITIES

Careful and extensive evaluation of congestion pricing programs introduced in the United States is the highest priority for research. Research is also encouraged in other areas as follows.

- The impact of congestion pricing on business logistics and commercial carriers.
- The extent to which transit services and revenues could be improved as a result of congestion pricing and how this might benefit lower-income users.
- Development of improved models for simulating household travel changes in response to pricing and other travel demand management strategies.
- Improved measures of congestion.
- Efficiency and productivity benefits of congestion pricing.
- Development of a program to ensure that the United States learns from current and emerging experiments with road pricing in other parts of the world.
- Measurement of long-term land use changes that might occur in response to congestion pricing.
- Studies of how the benefits and burdens of policies such as congestion pricing shift over time through labor, land, and retail markets.
- Constituency building and the local politics of implementation.
- The efficacy of distributing tradable permits to all motorists for driving during peak periods as an alternative to charging congestion tolls (this option would allow motorists to be "bought off" of congested routes rather than being "tolled off").

Source: Transportation Research Board and Commission on Behavioral and Social Sciences and Education 1994, Vol. 1, pp. 9–15.

the United States reflects the extent of urban decentralization in America over the past several decades. Many American downtowns are thriving, but those that are successful have given greater emphasis to tourism and economic activities that cater to visitors, such as conventions and trade shows. They have generally all been losing employment and retail sales relative to suburban areas that provide ample freeway access and acres of free parking. In an environment of vigorous competition for commercial employment and retail trade, few

American central business districts could achieve a consensus that area or cordon pricing is an appropriate technique by which to control traffic congestion. They fear that cordon pricing in the center will only accelerate the migration of economic activity to outlying suburban centers. In their pursuit of economic growth, American downtowns can be said to fear road pricing much more than they fear congestion.

It is also the case that the steady decentralization of residences and employment in America for more than 80 years has resulted in the more dramatic growth of congestion on regional freeways than on central city surface streets. Naturally, then, congestion pricing in the United States has been more facility based and located in suburban settings.

## HOT Lanes as a Road Pricing Innovation

A number of authors who participated in the *Curbing Gridlock* study had observed that Americans were even more likely than Europeans to interpret road use charges as punitive, especially because, in many more instances than in Europe, roads have already been paid for by hypothecated user fees in the form of motor fuel taxes. Trucking interests and automobile clubs have been complaining for decades that road user fees would constitute charging users a second time for roads that they have already paid for directly through fuel taxes, which are themselves "surrogate tolls." Given this background, it is easy to see that the more successful path to the adoption of road user charges in America consists of charging motorists directly for the production of completely new and beneficial travel options, and not charging them simply for the use of congested roads in order to regulate flows.

On the SR-91 project in Southern California, for example, four express lanes were added to an extremely congested freeway in a suburban setting, and users are charged to use the new capacity according to a toll schedule that varies with the level of congestion, while the preexisting lanes are not tolled. By capturing those willing to pay more to travel at higher speeds, the newer lanes create benefit for those who choose to use them and for those who choose not to pay but who face lower traffic volumes on the preexisting lanes. Such projects exemplify the specific conditions under which Americans, in an environment of politically prominent and universal hypothecated user fees, are willing to accept road pricing. They see marginal benefits in exchange for the marginal costs that are being imposed on them. Because of preexisting requirements that new capacity expansions provide special opportunities to high-occupancy vehicles (HOVs) such as carpools and vanpools, the SR-91 project at first allowed such vehicles to travel in the new lanes free, and this suggested a more general principle that has been more widely adopted.

Robert Poole, Kenneth Orski, and a number of other transportation innovators saw opportunities for similar win-win situations in the networks of HOV lanes that had already been built during the past 20 years in a number of American cities. To promote carpooling, vanpooling, and transit use, thousands of lane miles had been added to freeways but reserved for HOVs. While some of these lanes actually carry more people in the peak periods than adjacent general-purpose lanes, they often appear to be less crowded than those general-purpose lanes. Poole, Orski, and others advocated the conversion of HOV lanes that were being used below their full capacity to HOT lanes. HOVs travel free in such lanes, while additional single-occupant vehicles (SOVs) are allowed to buy their way in through payment of a premium fee or toll. Again, those paying the toll, who already paid for the roads through their fuel taxes, are not compelled to pay a toll but instead are given an opportunity to buy an upgrade in their travel. In San Diego County an 8-mile HOV lane in the median of a crowded Interstate 15 was converted to HOT-lane operation during peak periods starting in 1996. Since 1998 the price on this facility has been adjusted to reflect current demand in order to assure the HOV users that their travel will not be degraded by the SOV drivers who choose to buy their way into these lanes. In Houston, Texas, the Katy Freeway performed a pilot test that charged carpools of two people a fee to travel on a similar lane that was free to carpools carrying three or more people. Other regions, including Alameda County near San Francisco and Minneapolis, Minnesota, are considering the conversion of HOV lanes to HOT lanes or building new HOT lanes from scratch.

Later at this conference, others will provide you with more detailed accounts of these pioneering cases. I wish only to point out that they have made a huge difference in American policy making. They have moved congestion pricing from a hypothetical concept that many found frightening to a demonstrated concept that has worked to the advantage of many who initially had felt threatened by the concept. Many said that pricing would not work because people had little or no flexibility to change their travel patterns, and these lanes have shown otherwise. Originally derided as "Lexus lanes" that would serve the rich, premium lanes have been chosen by many users of many income circumstances on occasions when they are pressed for time who would have chosen the regular lanes on other days. One author at the *Curbing Gridlock* conference had feared that congestion pricing would discriminate on the basis of gender because male travelers often have more resources than women (Giuliano 1994). Yet some

women have opted for the HOT lanes because of the pressure of trips from work to child care locations and have reported benefits from the increased range of travel choices.

## Proving the Effectiveness of Electronic Toll Collection

Another important trend during the decade since *Curbing Gridlock* has been the widespread adoption of electronic toll collection technology throughout the United States. As recently as a decade ago, the lay public and elected officials simply did not believe that tolls were a practical way of either collecting revenues or controlling traffic congestion, because they envisioned manually operated tollbooths at which expensive employees made change and delayed traffic. While electronic toll collection using simple transponders has been most widely applied to bridges and roads that had flat tolls that do not vary with the level of congestion, their use by millions of Americans is proving that electronic tolls can be user-friendly and are technically feasible at acceptable operating cost.

There is no doubt that the dramatic national adoption of FasTrack and E-ZPass and other electronic toll payment systems is making road pricing more feasible and promising than ever. Familiarity with the operation of electronic toll collection is reducing opposition to road pricing. Gradually, by relying on electronic toll payment instruments, some heavily traveled facilities, including New York City toll bridges and the New Jersey Turnpike, have introduced modest price differentials based on time of day. While these fall short of full congestion-based pricing, they are clearly a transition toward it on a scale that I would not have envisioned to be feasible just a decade ago.

In Europe a number of countries have already adopted and others will soon adopt systems of weight–distance fees for trucks based on electronic tolling and vehicle tracking systems that incorporate Global Positioning Satellite Systems (GPSS). Similarly, several states in the United States are implementing or considering the implementation of such road user charges for goods movement (Forkenbrock and Kuhl 2002). Experiments are either already under way or in the later stages of planning in Atlanta, Minneapolis, and Seattle that apply GPSS technology to the monitoring of urban passenger travel to price automobile insurance or road use in more direct proportion to use and cost. While the general implementation of electronic road user charges for passenger cars based on time and location of travel is obviously not yet under consideration, increased experimentation and accumulated experience with trucks will continue to familiarize public officials and travelers with technological options that will become more acceptable over time.

## Growing Traffic, Financial Pressures, and an Emphasis on Management

Throughout the United States there is a widely shared perception that traffic congestion is worsening. While the reality varies greatly by location, it appears that this perception is generally accurate. Average daily vehicular volumes grew on urban Interstates by 43% between 1985 and 1999. In a study of 68 urban areas the Texas Transportation Institute reported that the percentage of daily travel taking place under congested conditions increased from 32% in 1982 to 45% in 1999 (Schrank and Lomax 2001); typical motorists faced 7 hours per day of congested roadways in 1999 compared with 5 hours in 1982. The Federal Highway Administration similarly reported that road delays, defined as travel taking more time than it would under free-flow conditions, increased by 8.5% between 1993 and 1997.

There are several reasons to believe that highway congestion will continue to grow. I indicated earlier that highway-related revenues are growing far more slowly than volumes of travel, and there is widespread unwillingness by elected officials to raise user fees in proportion to increasing costs. In addition, unit costs of construction and maintenance are increasing faster than the general Consumer Price Index. Higher proportions of state transportation budgets must be spent on maintenance and rehabilitation, which limits the availability of funds for new capacity. In addition, many metropolitan areas are spending higher proportions of their transport funds on transit investments, which limits the availability of funds for highways. Where new highways are built or existing ones widened, it is more necessary than ever to invest in mitigation measures that lessen the undesirable impacts of highways on communities but reduce the funds available for new capacity. Despite this, highway traffic is growing faster than transit use, and urban goods movement—which cannot be accommodated by transit—is growing at a faster rate than passenger travel.

For all of these reasons, more and more public officials are accepting that America will be expanding highway capacity much more slowly than highway use for the foreseeable future. This leads to the suggestion that we must do more to manage the capacity that we do have. This, in turn, is gradually leading to increasing—if still grudging—acceptance of pricing for the purpose of managing flow, especially where the management strategy is aimed, as it is on HOT lanes, at the efficient use of new capacity and the provision of new travel options.

## Emerging Prospects for the Coming Decade and Beyond

I expect that recent trends will continue in the United States and Canada. There will be steady but gradual expansion of congestion pricing in the face of continuing opposition and skepticism. While proponents of congestion pricing have long emphasized its potential contributions to the improvement of system efficiency, growing shortages of revenues are likely to be as influential as concerns about efficiency in the continued adoption of electronically priced congestion charges.

A few older American cities, such as New York and Boston, may eventually attempt area-based pricing strategies that emulate successes that have been achieved in Europe, but I expect facility-based applications of pricing to continue to be more common in America for reasons noted above.

Similarly, because strong objections remain to the "retrofitting" of congestion pricing on roads that have already been paid for by other sorts of user fees, I would predict that for some time to come pricing in North America is likely to be more commonly attempted at locations at which new capacity is being added in the form of additional lanes, such as HOT lanes, or where entirely new road facilities are being added to the network. In some cases, these could be new lanes that are specifically reserved for trucks and goods movement and that are paid for by tolls on the trucks that use them. Gradually, at specific bottlenecks, including heavily congested major bridges providing access to the cores of large urban regions, congestion pricing will be added as current toll schedules are revised, to manage flow more efficiently while increasing revenues.

I expect efficiency-based road pricing to be more widely applied to goods movement over the coming decade or two than to automobile traffic. Trucks, of course, pay more through user fees than do cars, and there is more concern that current pricing mechanisms do not charge them fairly. We expect the volume of goods movement to increase over the coming decade much more steeply than highway passenger traffic. The installation of electronic devices in trucks and the monitoring of truck movements through GPSS are much further advanced and much more politically acceptable than is the case with respect to passenger vehicles. I think it possible that truckers will support the construction of truck-only auxiliary lanes on existing but congested Interstate highways, to be financed by electronically imposed truck fees based on precise monitoring of truck weights and distances traveled on those facilities.

Gradually, as it is proven that emerging technology can facilitate more sophisticated pricing schemes without confusing travelers or customers, I would expect to see increased application of dynamic cost-based pricing to nonroad transportation. These approaches are already more common with respect to passenger air travel than road travel. I would expect to see additional applications to urban passenger transit systems in the form of increased use of off-peak discounts and distance-based fares. Such approaches may also be applied to far more sophisticated schedules governing the pricing of parking spaces at urban transit and commuter rail stations as well as at airports, sports stadia, and other venues that generate a great deal of automobile traffic.

Because equity continues to be an overriding concern in American politics and threatens to slow the progress of pricing unless it is addressed in serious and practical ways, greater experimentation with relating pricing to income and equity is also likely. For example, I would expect to see the introduction of lower-priced or "lifeline" rates for low-income travelers on some facilities that decide to introduce road pricing.

In the much longer term, perhaps over 20 or more years, it seems reasonable to expect that motor fuel taxes will eventually become obsolete as the primary source of road user–based financing. Whether fuel cells or other technological innovations become the principal means of powering motor vehicles, it is reasonable to postulate that policy makers will attempt to promote the adoption of new energy technologies by designing tax incentives to encourage their introduction. With the widespread availability of electronic toll collection, however, it is reasonable to think that user fees and hypothecation, long a mainstay of American transportation system finance, will evolve from reliance on the taxation of fuel purchases to the more direct pricing of travel at the time and place roads are used. This was, of course, originally contemplated in the 1920s. In fact, those who adopted the motor fuel tax at that time thought it was a temporary and second-best solution. I believe they were right, though their vision will have taken much longer to achieve than they could ever have imagined.

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RESOURCE PAPER

# One Step Forward, Two Steps Back?
## An Overview of Road Pricing Applications and Research Outside the United States

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This paper is offered as a complement to Martin Wachs's review of developments in the United States and Canada (Wachs 2005) and aims to summarize developments in road pricing elsewhere in the world. This is a substantial challenge, particularly because it is being written at a time of rapid development in the politics of road pricing internationally. We cannot claim to be expert in or wholly up to date in our understanding of all these developments. What follows should therefore be taken as a summary of the general context rather than as an accurate account of the current state of play internationally. We hope to learn more about these developments during the conference and will update this paper in the light of those findings. In the meantime, we apologize to anyone whose country's developments are inaccurately recorded here.

As Martin Wachs notes, developments outside North America have taken a different route from those he describes (Wachs 2005). All can trace their activities back to the seminal work of Pigou, Knight, and Vickrey but can now be seen as forming three broad groups. The first and most extensive is the work on road pricing in urban centers. Such pricing is usually based on charging to cross cordons or to be within them and is designed largely to reduce congestion and protect the environment; the London Congestion Charging Scheme is the latest and highest-profile outcome of this approach. The second is the development, as in the United States, of toll highways designed principally to raise revenue to finance the road. While few countries outside the United States have developed high-occupancy toll (HOT) lanes as an extension of this concept, Norway has introduced an alternative of toll rings, which are implemented on existing highways but are designed to finance new infrastructure. The third is the more recent development of proposals for distance-based interurban charging, initially for commercial vehicles but potentially for all traffic on congested roads. We review progress in all of these, starting with Europe and then considering Asia and finally, briefly, the rest of the world. We have, however, limited ourselves to schemes that reflect at least in part the original principles of road pricing; we have not attempted to review the wider field of toll highway developments.

We conclude this international review of policy developments with a summary of the state of play. The picture presented is one of many proposals but few successes, though, as Martin Wachs notes, the potential for real progress appears greater now than it has throughout the history of the subject. At the same time it is clear that there is a recurring set of reasons for failure to make progress: in particular concerns about public acceptability but also issues concerning equity, economic impacts, technology, and scheme design. Another characteristic of the differences between practice in North America and elsewhere is that many of these issues have been the subject of much more intensive research elsewhere in the world. To complement our review of policy developments, we therefore summarize key findings from these research programs. We conclude by assessing the potential over the next decade and identifying those aspects of the subject area remaining most uncertain.

## Policy Developments

### United Kingdom

The United Kingdom has perhaps the longest program of research into road pricing but had, until the recently introduced schemes in Durham and London, little to show for some 40 years of research.

The first major study, the Smeed Report of 1964 (Ministry of Transport 1964), was a model for much subsequent research. It set out clearly the congestion problem to be tackled (with its simple rule of thumb that at 10 mph each driver was imposing time losses on others equal to twice his own travel time), the inadequacy of alternatives to pricing, the criteria for design of an effective scheme, and the technologies available at the time. Its nine design criteria merit repeating here as an aid for today's designers:

1. Charges should be closely related to the amount of use made of the roads.
2. It should be possible to vary prices for different areas; times of day, week, or year; and classes of vehicle.
3. Prices should be stable and readily ascertainable by road users before they embark on a journey.
4. Payment in advance should be possible, although credit facilities may also be permissible.
5. The incidence of the system on individual road users should be accepted as fair.
6. The method should be simple for road users to understand.
7. Any equipment should possess a high degree of reliability.
8. It should be reasonably free from the possibility of fraud and evasion, both deliberate and unintentional.
9. It should be capable of being applied, if necessary, to the whole country and to a vehicle population expected to rise to over 30 million.

The Smeed Report was closely followed by a practical study of the relative merits of road pricing and parking controls in London, *Better Use of Town Roads* (Ministry of Transport 1967), which argued clearly for a simple form of road pricing within a cordon identical to that now in operation. The Greater London Council (GLC), which had been formed in 1965, developed this proposal further in a scheme entitled Supplementary Licensing (Greater London Council 1974; May 1975). Its preferred scheme was a charge of around £5 ($7.50) per day in 2003 prices to enter or be within an area defined by the Inner Ring Road between 0700 and 1900 on weekdays, with a charge of three times that level for commercial vehicles and exemptions for buses, taxis, disabled drivers, and emergency vehicles. It would have used prepurchased licenses and manual enforcement, much as in Singapore, with the costs of operation accounting for around 15% of revenues. It was predicted to have reduced car traffic entering the center by 45% and vehicle kilometers within the area by 35% and to have increased speed within the area by 40%. The impacts outside the area were predicted to be small but positive. The proposal came close to being accepted by GLC, which would then have had to seek legislation from government, which was thinking along similar lines in its transport white paper (Department of Environment 1976). Unfortunately, GLC decided not to pursue the proposal, mainly because of concerns over equity implications and impacts on the economy. Similar proposals emerged at the same time for Bristol and York, but this was a high point in the development of road pricing, not to be regained for another 20 years.

The reemergence of interest in road pricing in the 1990s stemmed from a growing realization that "predict and provide" policies were unlikely to succeed and a renewed interest in integrated transport strategies as a solution to urban problems (May and Roberts 1995). Several cities, including London, Edinburgh (May et al. 1992), Bristol, and Leicester, conducted integrated transport studies that demonstrated the benefits of road pricing as a means of controlling demand and financing other strategy elements, as discussed further below. However, it was the national government that commissioned the next major study, of London congestion charging, in 1992 (Richards et al. 1996). This again was comprehensive in its coverage, with investigations of alternative schemes, potential technologies, administrative and enforcement arrangements, and overall costs and benefits. It was recommended that charges be imposed for passing points in the road network or for being within a defined area. The previous proposals for a cordon around central London were reexamined. A charge of £10 ($15) per crossing was predicted to reduce traffic in the area by 25%, increase speeds by 32%, and generate revenues of around £400 million ($600 million) per year. The most complex scheme studied, with three cordons and four radial screenlines, was predicted to have a similar impact in the center but also to improve speeds in inner London by 10% and to generate almost twice as much revenue and three times the economic benefits (May et al. 1996b).

This study had been commissioned, but was not acted upon, by the last Conservative government. It was part of the evidence used by the incoming Labor government to decide to provide local authorities with the power to implement congestion charging schemes (and taxes on private parking) and to retain the net revenues for other transport projects (DETR 1998). This legislation was a breakthrough on three counts: it passed the initiative to local government, albeit with a requirement for approval by the central government; it allowed revenues to be

hypothecated for at least 10 years and thus addressed a key concern in public attitude surveys (Jones et al. 1996); and it established congestion charging as a potentially central element in an integrated strategy (May and Roberts 1995). Initially almost 30 local authorities expressed interest and joined the government's Charging Development Partnership. However, outside London only four or five remain interested, partly because the government has recently appeared less supportive and partly because it has been more willing to provide alternative funding for public transport schemes that might have been financed from hypothecated revenues. Durham introduced a single point charge on a sensitive road leading to the cathedral in 2002 and achieved a 90% reduction in traffic. Bristol is developing proposals for a single cordon, although recent changes in political control have raised questions over their development. Edinburgh has recently confirmed its proposals for a scheme with two cordons, one around the center and the other inside the outer ring road, and a charge of £2 ($3) to cross either or both; these will be the subject of a referendum in 2004. London's implementation of congestion charging in February 2003 has, of course, eclipsed all these developments. We will not describe it further here, since it is the subject of later presentations. However, it is worth recording that its design and impacts are remarkably similar to the proposals for supplementary licensing 30 years ago, with two notable exceptions: operating costs have proved to be a much higher proportion of revenues, which substantially reduces the finance available for other transport projects; and, crucially, the scheme has been implemented, while those of 1964, 1967, and 1974 gather dust on the shelves.

While most of the interest in the United Kingdom has inevitably focused on urban congestion charging, recent reports have advocated the use of distance-based charges nationally on congested roads, offset by the abolition of the annual vehicle tax and some reduction in fuel taxes (Commission for Integrated Transport 2002). A system of this kind is scheduled to come into operation for commercial vehicles in 2006, and a government field trial of the technology, based in Leeds, is expected to start shortly after some considerable delay.

## Norway

In Norway road pricing has long been used as a supplementary fiscal instrument to raise finance for road projects. Currently, 25% of the total annual budget for road construction in Norway comes from the road pricing schemes around the country (Odeck and Brathen 2002). Most of the road pricing schemes impose tolls on particular sections of trunk roads, tunnels, or bridges. Only five of them are urban charging cordon schemes (or toll rings): those in Bergen, Oslo, Trondheim, Stavenger, and Kristiansand. However, recently discussions have taken place concerning the modification of the current toll financing schemes to congestion charging schemes in Bergen, Oslo, and Trondheim.

The Bergen toll ring was introduced in 1986 with the aim of directly raising finance for completing the planned road system. In 1990 the capital city of Norway, Oslo, also introduced an urban toll ring, to finance a new tunnel under the city center. The implementation of the tolls in both cases was timed to coincide with the opening of the new tunnel and bypass projects financed by the toll revenues. In 1992 a toll ring was implemented in Trondheim, which has been gradually developed over the years since its introduction. An "amputated" toll ring with only two toll plazas was in operation from 1992 to 1996 in Kristiansand. A new package and toll charge period were recently agreed on to fund the construction of the new trunk road (E18) and two tunnels through Kristiansand. In 2001 Stavanger implemented a city toll ring. The toll will be in operation for 10 years to finance the new road and other transport projects. Table 1 summarizes the characteristics of the schemes in these five cases.

Given the original objective of raising revenues, the lower toll level in all schemes only reduced the traffic slightly (6% to 7% for Bergen, 3% to 4% in Oslo, and 10% in Trondheim during the charged periods). Originally, in Bergen the toll revenues collected were only used for road projects. A new agreement was reached in 2002 for maintaining the toll ring system until 2011, with the basic toll levels increased to 15 NKr from 2004 onward (which coincides with the implementation of electronic collection), only 45% of the revenues being allocated to road investment, and the scheme being refocused as a congestion charging system. In Oslo, Trondheim, Kristiansand, and Stavanger, the revenues will help finance road projects, public transport improvement, and other safety instruments. New toll ring schemes are also under way. In 2003 the Namdal project (in the city of Namso) started; it is claimed to be the smallest toll ring in the world (only two toll points). Tønsberg will decide on the introduction of a toll ring by 2004.

The toll ring system in Norway is currently at a crossroad. Most of the projects around the country were originally initiated to finance major local transport schemes (mostly road transport infrastructure). The agreements for many existing schemes are near their end or already terminated (the case in Bergen). A decision on the future of the toll rings has to be made. At the national level in Norway a new law on tolling and road pricing has just been sanctioned by Parliament. Through this law, road user charging is accepted as a means both for revenue raising and for demand management, but the two objec-

**TABLE 1 Key Characteristics of the Norwegian Toll Rings**

| | *Bergen* | *Oslo* | *Trondheim* | *Kristiansand* | *Stavenger* |
|---|---|---|---|---|---|
| City population | 213,000 | 456,000 | 138,000 | 70,000 | 103,000 |
| Starting date | Jan. 1986 | Feb. 1990 | Oct. 1991 | April 1992 | April 2001 |
| Number of toll stations | 7 | 19 | 22 | 5 | 21 |
| Charging regime | Uniform charge | Uniform charge | Peak and off-peak charge | Uniform charge | Peak and off-peak charge[a] |
| Entry charge for small vehicles (NKr)[b] | 10 | 15 | 15 (for all periods for manual payment)[c] | 10 | 10 (peak)<br>11 (off peak) |
| Charging period | Weekdays, 6 a.m.–10 p.m. | All days, all hours | Weekdays, 6 a.m.–6 p.m. | Weekdays, 6 a.m.–6 p.m. | Weekdays, 6 a.m.–6 p.m. |
| Discount | Discount for monthly subscriptions | Discount for prepaid tickets | Discount for users of electronic systems | Discount for monthly subscriptions | Several advance payment discounts with AutoPass |
| Annual gross revenues (NKr millions) | 156 | 1,046 | 168 | 95 | 80 |
| Annual operating costs (NKr millions) | 30 | 103 | 17 | 20 | 21 |

[a] Peak period: 7–9 a.m. and 2–5 p.m.; off-peak period: other times between 6 a.m. and 6 p.m.
[b] Heavy vehicles are charged double price.
[c] For prepayment of 6,000 NKr, 9 NKr between 6 and 10 a.m. and 6 NKr between 10 a.m. and 6 p.m.; for prepayment of 3,000 NKr, 10.5 NKr between 6 and 10 a.m. and 7.5 NKr between 10 a.m. and 6 p.m.; for prepayment of 1,000 NKr, 12 NKr between 6 and 10 a.m. and 9 NKr between 10 a.m. and 6 p.m.

tives can never be mixed. This means that today's tolling systems must be dismantled before any urban pricing scheme can be introduced. Public acceptance of these changes is also uncertain. While 54% opposed Bergen's toll ring before its implementation, that had fallen to 37% a year later. It is not clear whether toll rings designed for congestion charging will attract such majority support.

## Sweden

Sweden has had an interest in restraining traffic, particularly in Stockholm and Gothenburg, since the 1980s. Its main focus has been protection of the environment, although relief of congestion has also been an issue. The most significant proposal for Stockholm emerged in 1991 as part of the Dennis agreement (Gomez-Ibanez and Small 1994). The Dennis package involved relieving traffic problems in the inner city by improving public transport, building an inner ring road and a tolled western bypass, and introducing a toll ring just outside the inner ring road. Tolls would have been around $2 at current prices, with the possibility of variations by time of day and by standard of emission controls. With the outer bypass tolls, they would have been designed to provide the main source of finance for the investments. While the proposals initially had the support of all the main political parties, it soon became clear that both the inner ring road and the toll ring were highly controversial, and the proposals were dropped in 1997. However, other agencies, including the Swedish Society for Nature Conservation, the Swedish Institute for Transport and Communications Analysis, and the Swedish Environmental Protection Agency, have since submitted proposals for somewhat similar pricing schemes. Most recently, the Swedish National Road Administration has published a review of the options for road pricing in urban areas (Eliasson and Lundberg 2003). While the review does not make specific proposals, it is one of the most comprehensive summaries of successes and failures in road pricing currently available.

## The Netherlands

During the late 1980s, the Dutch government proposed the introduction of a large multiple cordon-based road pricing system called *rekening rijden* ("road pricing") for the Randstad region (including Amsterdam, Rotterdam, The Hague, and Utrecht, plus part of the province of Noord-Brabant). The main objective of this proposed scheme was to manage travel demand and hence to reduce congestion. Other objectives were to decrease environmental pollution and generate funds to finance new infrastructure. Because of public opposition the proposal was not pursued. In 1991 a more conventional form of road toll using toll plazas (*tollpleinen*) was proposed. The objective of the scheme was redefined to raise money for road infrastructure. However, the potential disruption of the traffic attributable to the stop-and-go operation of the toll plazas and the amount of land required for implementation caused the proposal to be rejected.

In 1992 a proposal of reduced scope, which involved a system of supplementary licensing for motorists using the main road network during peak periods (*spitsvignet*), was discussed. The peak-hour motorists would have been charged a fixed toll to travel during peak hours regardless of the area. The charge would be about $2.85 per day (1992 prices) applied during the morning peak period, 6 to 10 a.m. However, the proposal was not approved after a new government was elected in 1994. Boot et al. (1999) suggested that the most important reason for the failure of these earlier proposals was political acceptability.

Subsequently, in October 1994 the Dutch parliament agreed in principle and strongly proposed the implementation of a revised form of rekening rijden (referred to as "congestion charging"), which would be a system of electronic toll cordons around the four main cities in the Randstad area starting in 2001 (Dutch Ministry of Transport 1995). The charge would be in operation during the morning peak hour (7 to 9 a.m.) on weekdays. The objective of this late proposal was to improve accessibility of the economic centers. In 2001 congestion charging became a major political issue in the Netherlands. The proposal of rekening rijden was opposed by several interest groups. The main objection was that the authorities failed to provide an alternative for those who were obliged to travel by car during the proposed charging period. The government is now considering an alternative proposal for a *Mobimeter* ("kilometer charging") system. The idea was supported by the successful development of the technology for the kilometer charging system. In addition, the policy could well fit in with the European Commission white paper that proposed a kilometer charging system as a good instrument for transport pricing in Europe. The cabinet has now announced a proposal for legislation on the kilometer charge by the end of 2003 and stated its intention to start implementing the system in 2004 (the system is expected to be fully operational by 2006). The system will be a nondifferentiating kilometer charge first, but the possibilities of differentiating the charge in relation to congestion will be discussed further.

The barriers to the success of the implementation of congestion charging in the Netherlands have been politics and technology. The success of the recent proposal for a kilometer charge will rely heavily on the reliability and capability of charging technology. However, the greatest barrier to further progress still appears to be political and closely linked to public acceptability.

## Germany

The key development of road user charging in Germany is the implementation of interurban freight charging. Since April 2001 there has been a standard emission-related tariff for motorway tolls applicable to heavy goods vehicles (HGVs), jointly implemented by Belgium, Denmark, Germany, Luxembourg, the Netherlands, and Sweden (Eurovignette). The current system of Eurovignette imposes a license charge on all HGVs weighing more than 12 tonnes (except buses, coaches, and specialist vehicles) for using the road network in any of these countries. The charges are varied according to the number of axles and engine emission standards.

Germany is facing the problem of continuing freight traffic growth as the consequence of the Single European Market and the enlargement of the European Union (EU) to the east and globalization. Freight traffic is forecast to grow by 64% before 2015. The German government aims to tackle the problem by creating an efficient transport infrastructure to accommodate the growth in traffic demand, improve the rail freight network, and create fair competition between modes. One key strategy is to rectify the price ratio between the rail and the road sectors. Thus, after a long discussion, the introduction of distance-related charges for the use of motorway system by HGVs was approved by the government in April 2002. The act allows the introduction of distance-based charging on the motorway network and some part of the federal highways (mainly for safety reasons), and the toll revenues can be used for infrastructure projects.

The toll system will be changed in autumn 2003 from the old Eurovignette system to the kilometer charge system. The charge will still be differentiated according to engine emission standard and number of axles. It will replace the Eurovignette and some part of the fuel duty. The charge is expected to vary between €0.10 and €0.17 per kilometer and is in line with EU Directive 1999/62/EC (Commission of the European Community 1999). Driv-

ers will have two charging options. The first is the automatic charging option, which is for vehicles equipped with an onboard unit. This automatic electronic system can be located exactly by satellite and continually transmits the position of the vehicle, the company and vehicle data, and the kilometers traveled on charged roads to a central computer. An automatic procedure then charges the toll in arrears to a preselected payment partner. The second option is the manual prebooking system. The manual procedure requires that the driver or the vehicle's owner stipulate a route in advance and "buy" the route at one of the toll terminals or via the Internet before the journey.

## Other European Developments

The European Commission has conducted research over several years into marginal cost pricing and its application to policy [Nash and Matthews (2001) give an overview]. Its 2001 transport policy sets out clearly its aspirations for a more effective pricing policy for all transport (Commission of the European Community 2001) and indicates the principles to be adopted for transport infrastructure charging. In particular, it promotes equal treatment of all operators and modes, argues for charges that internalize external costs, and states that charging revenues should be channeled into specific national or regional funds to finance measures that themselves reduce external costs. By these means, it argues, a double dividend is obtained. However, the commission is limited in the extent to which it can influence the decisions of individual member states. It is able to assess the acceptability, from a European perspective, of proposed changes in charging structures (and is currently reviewing the United Kingdom's plans for distance-based charging for commercial vehicles), but it can only encourage governments to introduce charges in the first place. It notes that the proposals leave each member state wide scope in terms of implementation while offering a common methodology for setting price levels. At a more detailed level, a new European directive on interurban freight charging was released in 1999 (Commission of the European Community 1999), which aims to revise the current Eurovignette system. Several countries have been considering the possibility of a more advanced interurban HGV charging system, including Germany (as mentioned earlier) and Switzerland.

One of the commission's main tools for providing encouragement is demonstration projects, and two related research projects in its Fifth Framework research program involve the implementation of demonstration projects (PROGRESS) and their evaluation (CUPID) (Baker 2002). Among these eight demonstration projects, Bristol, Edinburgh, and Trondheim have been mentioned above. Two, in Gothenburg and Copenhagen, involve small field trials coupled with attitudinal and behavioral research into the likely impacts and acceptability of different road pricing schemes. One, in Helsinki, involves only desk-based and attitudinal research into alternatives. The other two are access control schemes in Genoa and Rome, to which charges might be added. In Rome, some classes of drivers already pay for access permits, and so a simple form of road pricing already exists (Tomassini 2002). These are of interest, since the widespread use of access controls in Italian cities, with only vehicles that have been allocated permits allowed to enter, has been seen as an alternative to charging as a means of controlling car use and has had some success (Topp and Pharoah 1994). The current proposals envisage drivers allocated permits (because they are residents or have business premises in the area) still being able to enter free of charge, but with others being able to pay to do so, thus making more efficient use of the road space. The technology is in place to check permits automatically and to identify those who have paid to enter.

Without exception, these pilots have taken longer to implement than had been anticipated when the research program was developed in 2000. In all cases, political uncertainty reinforced by critical public opinion surveys has been the main barrier to progress, although in one or two cases problems with new technology have also delayed implementation. Paradoxically, only the London scheme, which was not part of PROGRESS, and to a lesser extent the Norwegian toll rings that predated it will provide real evidence to other European governments of the benefits of urban road pricing.

## Singapore

Given the limited land space, the Singapore government has foreseen the possible severe impact of traffic congestion on the development of the country (Foo 2000). The government has been trying to control the level of car traffic in the network through various generations and combinations of pricing measures over the past 30 years. Two means of controlling car travel demand have been adopted: the control of vehicle ownership and the restraint of vehicle usage.

A tax was imposed on new vehicle registrations in 1972, and tax rates were subsequently increased as a means of controlling ownership. However, there was concern that the tax was inflexible and that it was not imposing sufficient control. In 1990 the government introduced a unique form of vehicle ownership control, the vehicle quota system (VQS), in which a quota for new vehicles in any month is determined to match an approved overall growth rate of 3% per year and the payment is determined by a bidding system. After the

implementation of the VQS, the average annual motor growth rate was decreased to around 2.83% from 4.4%. The VQS also generated a substantial amount of revenue for the government (around $1.8 billion in 1994 alone).

Although additional taxes had been in place since 1972, the Singapore government was not satisfied with the effectiveness of this measure in curbing congestion. In 1975 Singapore introduced the world's first urban road pricing scheme, the area licensing scheme (ALS), to increase the incentive for car users to switch to public transport. The original ALS was a single cordon covering the central business district (CBD) of Singapore, called the restricted zone (RZ). Under the ALS, a permit had to be purchased to travel into the RZ by car during peak traffic periods, with exemptions for those with four or more people (Holland and Watson 1978). Enforcement was based on manual operation by police personnel located at each of the entry points. The morning peak car traffic volume entering the RZ in 1992 was approximately one-half the level 17 years earlier, before the ALS was introduced. Speeds had increased by 20%, and accidents had fallen by 25% (Menon 2000). Public transport's share of working trips increased from 33% in 1974 to 67% in 1992.

Initially, the charge structure was simply a flat rate charge of S$3 for traveling inside the RZ in the a.m. peak period (7:30 to 9:30 a.m.) on Monday through Saturday. However, 3 weeks later the charging hours were extended until 10:15 a.m. in response to the substantial increase in traffic volume entering the RZ just after 9:30 a.m. (Chin 2002). The charge was then increased to S$4 and S$5 in 1976 and 1980, respectively. Gradually, the structure of the charge and the charging period were modified to increase the effectiveness of the scheme. In 1989 the charge period was extended into the p.m. peak (4:30 to 7:00 p.m.) with a charge level of S$3. The charge period was extended again to the whole day from Monday through Friday in 1994 with the same charge level of S$3. The ALS was considered successful, and it was claimed that there were no significant impacts on businesses inside the RZ (Seik 1998).

Nevertheless, the original ALS also had unintended adverse effects such as congestion on feeder roads and expressways leading to the CBD (Goh 2002). The government decided to introduce the road pricing scheme (RPS) to regulate traffic on the expressways and feeder roads in 1995. The RPS (manually operated) was implemented on the three main expressways heading into the CBD with congestion tolls to pass defined points. About 16% of motorists stopped using the expressways during the RPS operation hours (between 7:30 and 9:30 a.m.). However, the ALS and RPS were claimed to cause underuse of the roads within the CBD and not to be able to deter the congestion outside the RZ. In addition, the manual operation of both systems was too labor intensive and not flexible enough to permit future modification.

In 1998 the electronic road pricing system (ERP) was implemented. The ERP cordon covered an area similar to the original RZ of the ALS. However, the charge is imposed on a per crossing basis, which is different from the original operation of ALS. An incomplete second cordon has since been implemented. The ERP charge rates are set on the basis of type of vehicle (including motorcycles). The charges are also differentiated according to location of crossing, day, and time of day. The road authority in Singapore reviews speeds quarterly on the expressways and roads where the ERP is in operation. After the review, the ERP rates are adjusted to maintain average traffic speed on expressways and roads inside the RZ at 45 to 65 kilometers per hour and 20 to 30 kilometers per hour, respectively.

Immediately after the implementation of the ERP, traffic volume on the heavily congested roads fell by 17% from the condition during the operation of ALS. Traffic volume into the CBD decreased by 10% to 15% compared with the condition during the ALS operation (Chin 2002). The ERP has been effective in maintaining a speed range of 45 to 65 kilometers per hour for expressways and 20 to 30 kilometers per hour for major roads as intended. The estimated monthly revenue from the system is S$3.4 million, which is substantially lower than the revenue collected from the old ALS and RPS schemes, about S$5.8 million per month (Goh 2002). The change of the fundamental principle of charging from ALS, which allowed multiple entries for the whole day, to the ERP, which charges per crossing, is the reason for the significant drop in demand despite the lower charge rates.

The Singapore government has adopted a "stick and carrot" policy under which a substantial amount of money has been invested in improving the public transport system. After gaining sufficient revenues from ALS, in 1988 the government decided to develop the Mass Rapid Transit, which is the network of heavy rail, and later a light rail network (initiated in 1999). The development of public transport has enhanced its modal share, which increased from 46% to 70% of all journey-to-work trips to the CBD between 1976 and 1991. The Singapore Land Transport Authority (LTA) plans to modify the charging area and charge levels to achieve better utilization of the road network while maintaining an acceptable level of service. Although there has been a wide range of well-documented papers on the success and implementation path of road pricing in Singapore, there has been little discussion of public responses. The stable political climate in Singapore has supported the government and LTA in adopting an aggressive transport policy over the past three decades. Despite all the successes, questions have been asked about the extent of

decentralization of the city and the economic impact of the cost of the journey to work (Phang 1993; Willoughby 2001).

## Hong Kong

In 1982 the Hong Kong government decided to adopt fiscal controls to contain traffic. Particular measures introduced were the trebling of the annual fee for private cars and the doubling of the fuel tax and the registration fee for new cars. As a result of the vehicle ownership restraint, private vehicle ownership decreased from 211,000 in 1981 to 170,000 in 1984. However, the level of congestion was only reduced in the least congested (low-income) areas and during the same period rose in the most congested areas (Dawson and Brown 1985). Private car and taxi use remained high, particularly during peak periods (Lewis 1993).

In response to this failure, in 1983 the Hong Kong government decided to commission a 2-year investigation of the viability of introducing a road user charging scheme using an ERP. The Hong Kong government chose not to adopt a low-tech option like the ALS in Singapore on the basis that it would be too liable to fraud and require a considerable amount of enforcement (Borins 1988). The principles of the proposed ERP were similar to those of the current ERP in Singapore (with a charge per crossing). Three schemes were designed with different locations of charging cordons, screenlines, and charge structures. The designs were primarily intended to cover the most congested areas, Hong Kong Island and Kowloon. The charge structure was planned to vary by time period and area. The combinations of different charging cordons and screenlines with different charging structures followed the idea of a theoretical optimum (Dawson and Catling 1986).

The system proposed in the 1983 study was based on automatic vehicle identification with a passive electronic number plate mounted underneath the vehicle. At the charging points, inductive power and receiver loops installed underneath the road pavement surface would be used to detect and identify the vehicle crossing the point. The information of crossing vehicles and their crossing times would then be transmitted from the roadside computer to the main accounting and billing system. The motorists crossing the charging points would then receive a bill monthly. Enforcement would be conducted via closed-circuit television, which would record the rear number plates of the vehicles. Technological tests with around 2,600 cars confirmed a high reliability rate for the system. The proposed ERP was expected to decrease the traffic volume by at least 20% during the peak hours, and the capital cost of the scheme was estimated to be around $30 million (in 1983) (Borins 1988).

After the success of the technological trial and the potential positive outcome of the ERP, the Hong Kong government decided to consult the district boards, which represented the public. The government faced two main arguments: the need for road pricing given the scale of the congestion problem and the potential for invasion of privacy. In early June 1985, the proposal of the ERP was unanimously turned down by the district boards (Leung and Liu 1985). Borins (1988) discussed various tactical and political errors in the process of developing and selling the ERP to the public.

In 1994 the Hong Kong government revived the idea of tackling traffic congestion by road pricing. The government commissioned a major feasibility study, which began in March 1997, with the objective of examining the practicality of implementing ERP in Hong Kong. Various technological alternatives were considered, including the dedicated short-range communications (DSRC) system as currently operated in Singapore and the vehicle positioning system (VPS) based on the Global Positioning System (GPS). A cordon-based charging scheme was still the preferred alternative for the charging regime. Like the scheme designed in 1983, the charging zone would cover the most congested areas of Hong Kong and be operated on a directional and time period basis. The initial suggestion was that the peak-period charge would be from 8:00 to 9:00 a.m. and 5:30 to 7:00 p.m. A slightly lower charge would be applied during the interpeak hours. The charge rate would be set to maintain a target speed of 20 kilometers per hour. It was estimated that the implementation of the proposed ERP would reduce car trips entering the charging zones by up to 50%, with 40% diverting to public transport and 10% changing travel time. To rectify the failure of the first proposal, there was a well-planned public consultation program to allow public input into the development of the scheme.

Technology trials were conducted in late 1998 with both DSRC and VPS technologies. The results showed that both DSRC and VPS could be adopted in Hong Kong and that the privacy issue could be overcome. However, in 2001 the government concluded that on the basis of the feasibility study report in 1999 there were no transport and environmental grounds to justify ERP (Legislative Council 2001). Therefore, the government decided not to pursue the implementation of the ERP, despite the promising results of the technological trials. Although the technological barrier in relation to the privacy issue has been overcome, the question of the political and public acceptability of ERP remains.

## Other Asian Developments

Especially in Asia, the rapid growth of the economy has catalyzed the growth of traffic and vehicle ownership. In

Seoul, after several decades of rapid growth in car usage, the Seoul metropolitan government (SMG) has taken several measures to reduce congestion in the inner city and increase the mode share of public transport. Since 1993 the government has been investigating different traffic demand management techniques through various fiscal tools including congestion charging. In 1996 SMG implemented congestion tolls (around $2.20 for both directions) on two main tunnels linking the downtown area to the southern part of the city (Hwang et al. 1999). The objectives of this implementation are threefold: to reduce the incidence of low-occupancy vehicles, to raise revenues for transport-related projects, and to assess the effectiveness of the pricing technique. Private cars with three or more passengers are exempted from the tolls. Traffic volume decreased by 20% in the first 2 years after the operation. Average traffic speed increased by 10 kilometers per hour. A proposal for expanding the current congestion charging system in Seoul has been developed that is based on point charging. However, this expansion of congestion charging has not been implemented to date because of political concerns.

After the success of the ALS implementation in Singapore, in the 1970s the World Bank funded studies of the feasibility of implementing a similar scheme in Kuala Lumpur (Malaysia) and Bangkok (Thailand). Although the studies strongly supported the implementation of the schemes in both cities, initial setbacks have delayed implementation. In Kuala Lumpur, gantries were already installed at various points around the charging zone boundary. However, the operation of the ALS was ultimately deferred by the government. The reasons given were that the city needed to improve public transport and complete the inner ring road as an alternative for through traffic first (Armstrong-Wright 1986). In addition, it was claimed that the success of other road improvements at that time was able to reduce the congestion problem sufficiently in the central area. Interestingly, the same political decision makers both approved the initial plan and deferred it later. In Bangkok, the proposal for the implementation of ALS was immediately rejected by the government because of political concerns. On the one hand, there has been no implementation of any form of congestion charging systems in these cities to date. On the other hand, Thailand, Malaysia, and other countries in the region (including the Philippines, China, and Taiwan) have been progressive in using road pricing as a means to finance road infrastructure projects. There are various road toll projects both in urban and interurban contexts in these countries (with the sole objective of financing road construction).

In Japan, the Tokyo metropolitan government (TMG) developed the Transport Demand Management Tokyo Action Plan in 2000. The plan envisages future implementation of road pricing in the center of the city. TMG set up a committee to examine the possible implementation of the road pricing scheme. In 2001 the committee produced a report that proposes four different charging cordon designs. In early 2001 an electronic toll collection system was introduced in the Tokyo area; it was expanded to cover more than 600 existing toll points and went nationwide in November 2001. The initial purpose of this electronic toll system was for financing, but the emerging policy in Japan is to price roads differentially to reflect congestion and environmental impacts. Currently, experiments for congestion and environmental charging are being conducted in various locations.

### Elsewhere

There are a few road pricing proposals elsewhere in the world, and most of them are using road pricing as an infrastructure financing tool rather than as a congestion charging measure. In Australia, several high-technology tolling systems are in place: a series of tolled motorways, bridges, and tunnels in Sydney; City Link in Melbourne; and Gateway Bridge/motorway and Logan motorway in Brisbane. The interesting issue for Australia is the national policy to allow a customer of one toll road operator to be able to use other toll road systems "seamlessly." In the recent AusLink Green Paper, the possibility of moving the existing toll financing scheme to a congestion charging scheme is mentioned (Department of Transport and Regional Services 2002). A road user charging system for HGVs based on variable weight and distance (a mass–distance regime) was also referred to as an alternative. In New Zealand, the paper-based road user charges for HGVs, introduced in 1977, is a weight–distance tax relying on vehicle distance measurement devices. The purpose of this system is to recover road costs from heavy vehicles. In 2002 the government announced its intent to introduce an electronic road user charging system to increase fairness and efficiency of the charging system to vehicle operators. Migration from the paper-based system to the new electronic system will be voluntary. Currently, a feasibility study is being carried out to investigate the business case and functionality design. There have been road pricing proposals in South America. There was an early feasibility study of implementing road pricing in Caracas, Venezuela. More recently, the city of Santiago, Chile, has outlined a plan to implement an urban road pricing scheme.

## Implications

As noted earlier, three approaches have been developed outside North America.

Most effort has been put into the design, development, and implementation of urban road pricing. However, with the exceptions of London and Singapore, no significant scheme has yet been successful. This remains the least effective area of policy development, and it is important to understand the barriers to progress. The most widespread is political unacceptability, but concerns are also raised about equity and economic impacts; indeed, these underpin many of the wider concerns about acceptability. To a much smaller extent, the feasibility of pricing and of the supporting technology and the potential presented by that technology for invasion of privacy remain concerns. There is a growing interest in the design of alternative charging regimes and their integration with other policy instruments as ways of overcoming these concerns. All of these issues have been the subject of research, and we consider these research results further in the next section.

As in North America, there has been widespread use of toll highways as a means of financing the roads themselves. Uniquely, Norway has taken this principle and applied it to the existing infrastructure by using toll rings to pay for new infrastructure. This has clearly been successful in Norway, but no other country has implemented similar financing strategies. Norway is now facing the question of the future of these toll rings once they have generated the necessary revenues. It has been accepted that they might continue to be used to finance further (usually public transport) projects and to reduce congestion. However, it is as yet unclear whether toll rings designed for one purpose are necessarily suitable for another and very different purpose.

The third and most recent development has been the interest in using distance charging to manage congestion and to charge more appropriately for road use on interurban road networks. The German system for charging heavy commercial vehicles will be the first such scheme, and the United Kingdom is likely to follow in 2006. At present it appears that it will be another decade before such controls are imposed on all traffic.

## Research Issues

### Acceptability

A large number of surveys of attitudes toward road pricing have been carried out since the 1980s, particularly in the United Kingdom. This summary is taken from a fuller review available from the authors (Jaensirisak et al. 2003b) that provides a full list of references. Selected references are cited below.

A total of 29 surveys in the United Kingdom between 1989 and 2002 found levels of public acceptance of road pricing ranging from 8% to 76%. Clearly, other factors are influencing acceptability, and much of the research has focused on these factors. One of the clearest is the question of hypothecation; among the surveys, average acceptance was 35% where there was no hypothecation and 55% where there was.

Numerous studies illustrate the critical impact of hypothecation on acceptability. Jones (1998) concluded, "Most professional and governmental bodies in the UK now accept that hypothecation of revenues will be part of the price that will have to be paid to gain sufficient public support for urban road pricing to ensure its introduction in this country." There is, however, inconsistency across the results of different studies. Some have found that the greatest impact is obtained from spending on improved public transport, while in others it is investment in the road network and in yet others it is reduction in taxes.

Acceptability has been found to be influenced by attitudes to transport problems and the perceived effectiveness of the scheme (PATS Consortium 2001). It is also influenced by attitudes relating to the environment and toward the hazards of car traffic. Those who are concerned about the quality of the environment and negative effects from traffic are more likely to accept charging than others. On the contrary, those for whom the car has positive images tend to oppose charging. Some people use their cars because they enjoy doing so rather than through necessity, which leads to resistance to policies aimed at reducing car use (Steg and Tertoolen 1999).

Other attitudinal aspects of acceptability relate to perceptions of freedom and fairness (Jones 1998; PATS Consortium 2001) and concerns over equity issues (Giuliano 1992; Langmyhr 1997). Indeed, a distinction can be made between selfish and social perspectives. An interesting point about congestion was observed by Sheldon et al. (1993), who stated "no-one appears willing to accept that they contribute to the problem: it is typically something that is caused by someone else." Nonetheless, Rienstra et al. (1999) recognize that social concerns do influence preferences toward road pricing, while Schade and Schlag (2000) identified social norms as important.

Acceptability is likely to relate to personal characteristics and constraints, which may include income, age, education, transport mode used, frequency of car use, availability and quality of alternative modes, location of household and workplace, household type, and lifestyle. However, it is clear from a number of studies (Schade and Schlag 2000) that socioeconomic factors have a somewhat lesser impact on acceptability than do attitudinal factors.

The importance of the communication process to acceptability—making clear the main objectives, addressing public concerns, and spelling out the bene-

fits—has been highlighted (Schade and Schlag 2000). The benefits that will influence acceptability are the time savings and environmental improvements. However, it is uncertain that travel time reduction and environmental improvement are perceived by the public to compensate for the charge (Giuliano 1992; Harrington et al. 2001).

System features will influence acceptability. There is a preference for simple systems (Bonsall and Cho 1999), although Schlag and Schade (2000) found little difference between distance-based, congestion-based, and cordon pricing.

Last but not least, the level of acceptability of road pricing can be expected to be critically dependent on the level of charge. In almost all cases where the charge has received attention, no quantified relationship between acceptance and the charge has been developed (Schade and Schlag 2000; PATS Consortium 2001). Although details are not provided, Hårsman (2001) states that "acceptance relates to the level of charges and to the use of toll revenues. Experiences from the PRIMA case cities indicate that fairly low starting levels are needed and that the charges can be increased successively to meet financial requirements." The notable exception in this context is the Harrington et al. (2001) study, which quantified the effect of congestion pricing on voting behavior.

Our own research (Jaensirisak et al. 2003a) has attempted to fill some of the gaps in this understanding and developed relationships that enabled acceptability to be estimated in terms of the characteristics of the scheme. While we found road pricing to be unacceptable to the majority, some personal characteristics made it more or less so. Charging was more acceptable to non-car users, those who perceived pollution and congestion as very serious, and, to a lesser extent, those who considered the current situation unacceptable and who judged road pricing to be an effective means of reducing congestion. Conversely, older respondents were more likely to judge charging as less acceptable. Somewhat surprisingly, income did not influence acceptability.

Among the potential impacts of charging, an ability to achieve substantial environmental improvements was the single most important contributor to increased acceptability, followed by contributions to reducing delayed time for cars. There was a preference for using the revenue to reduce taxes, but the impact was small. As expected, design features were found to influence acceptability, which could be increased by limiting charging to the central area and, to a lesser extent, peak periods; using cordon-based charges rather than continuous charging regimes; and imposing lower levels of charge.

By combining all of these results, it proved possible to specify design combinations that would be voted for by the majority of the population. In London a cordon charging scheme limited to the central area with a charge of £5 per day (equivalent to the scheme since implemented) would be acceptable to the majority, and a charge of £7 would be, provided that it generated substantial environmental benefits and reductions in delay for cars. In Leeds, charge levels of £2 or £3 would be acceptable to the majority, but only given substantial environmental improvements and reductions in delay for cars.

## Equity

Equity issues have been a focus of concern for a considerable time (Cohen 1987; Else 1986; Small 1983). Various definitions and dimensions of equity as a result of road pricing have been suggested. Viegas (2001) and Jones (2002) pointed out that the definition of equity in transport largely concerns fairness of the right of access to transport infrastructure for different groups of people. This raises the question of whether road pricing is a fair allocation mechanism among different groups of individuals. Giuliano (1994) suggested that the equity issue in road pricing must consider both the distribution of benefits associated with reduced congestion (including side benefits such as pollution reduction and improved public transport service) and the distribution of costs needed to achieve the congestion benefits. Schade and Schlag (2003) suggested the psychological view on the issue with the reference to the term "justice," which may be different from the idea of a fair allocation mechanism.

Regardless of the exact definition of equity, for analytical purposes it is necessary to define groups of potential winners and losers from road pricing (Langmyhr 1997). In the main, there are two dimensions of equity: vertical and horizontal. The vertical dimension of the equity issue concerns the unequal impact from the scheme across different groups of the population segregated by income and socioeconomic characteristics. For instance, one may argue that the implementation of a road user charging system will benefit the rich while disadvantaging the poor (or lower-income group). The vertical equity analysis is mostly associated with the protection of those in the worst conditions (PATS Consortium 2001). Jones (2002) referred to vertical equity as social equity. The horizontal dimension of the equity impact is referred to as the spatial equity impact or territorial equity. The horizontal equity impact can be described as the impact on the population living in different parts of a certain area. If the scheme benefits only a small group of people from some areas but the rest of the population experiences a decline in social welfare, the scheme can be argued to be inequitable.

Early attempts in dealing with the equity issue were mainly involved in analyzing the impact of road pricing on vertical equity (Anderson and Mohring 1995; Frid-

strom et al. 2000; Giuliano 1994; Gomez-Ibanez 1992; Langmyhr 1997). A general conclusion from various researchers was that low-income or less flexible car users (e.g., based on gender or flexibility of working schedule) are likely to be the worst-off groups as a result of road pricing. If revenues are not redistributed in any way, road pricing generally results in gains for higher-income groups and losses for lower-income groups (Else 1986; Cohen 1987). The way the revenues are distributed has a significant impact on the equity issue (Fridstrom et al. 2000; Giuliano 1994; Small 1992).

Some research has examined the horizontal dimension of equity. Fridstrom et al. (2000) analyzed the spatial impact of road pricing cordons by using spatial accessibility for each zone segregated by modes as the indicator. They suggested that the main adverse impact of a charging cordon is its boundary effect, which also depends on the actual design of the scheme. A small cordon would affect residents inside the cordon the most, whereas those outside the cordon are the main victims in a wider cordon scheme. In the study of the Singapore ALS, Holland and Watson (1978) indicated that the cordon gave more advantage to the commercial firms outside the cordon. Obviously, this problem may be eliminated by the introduction of a different charging regime, such as a time-based, a distance-based, or a delay-based regime (Jones 2002). Halden (2003) also used the accessibility ratio between car and noncar from different zones for different purposes. The results showed a great diversity of the impacts on different areas in the city and classes of users.

Recent research has examined the approach to including equity aspects in the design of road pricing systems. Mayeres and Proost (2001) proposed a weighted welfare indicator giving more weight to the benefit–cost incurred by less advantaged groups. The test results showed that road pricing is an important element of the tax reform even with a greater emphasis on equity. Meng and Yang (2002) developed a framework for calculating optimal road toll (to maximize social welfare) with constraints on the spatial equity impact. Recently, Sumalee (2003) proposed an analytical method to identify an optimal location of charging cordon with spatial equity constraint. Jones (2002) proposed a simple approach to address equity concerns through scheme design, exemption, and discount.

While there remain some uncertainties over equity impacts, they mainly relate to issues of scale, which will depend on detailed design, and of design approaches, which can be adapted to mitigate these impacts.

## Economic Impacts

The economic and relocation impacts of transport schemes are notoriously difficult to measure or predict. For road pricing, the lack of empirical evidence makes the problem worse. The early study of area licensing in Singapore did not attempt to assess the impacts on land use. It did ask businesspeople for their assessment of the scheme, which was largely positive, but this may well have reflected a general view in Singapore at the time that government was making the right decisions. Ten years later an attempt was made to assess the impacts retrospectively. It was concluded that there was no evidence of adverse impacts on economic activity in the city center (Armstrong-Wright 1986). However, this assessment was made difficult, both because parking restrictions had been introduced at the same time, about which businesses were much more critical, and because the Singapore economy had expanded rapidly in the intervening period, which masked any impact of road pricing. There is no documented evidence of any similar assessments in Norway. Empirical evidence is being sought in London in the context of early claims of a roughly 10% reduction in retail trade.

An earlier study asked businesses in three cities—Cambridge, Norwich, and York—about the expected impacts of a road pricing scheme charging £3 per day to enter the city center in the morning peak (Gerrard 2000). The majority anticipated positive impacts on the environment and congestion but negative impacts on the economy and tourism and on their own staffing and profitability. When asked whether road pricing would influence their next location decision, 53% said it would and 26% that it might.

Model-based predictions typically suggest much smaller impacts. An analysis of the impacts of congestion charging in London was carried out by using the MEPLAN model of London and the South-East, which reflects the effects of changes in accessibility on location (May et al. 1996a). For a £4 charge to enter central London, the predictions were as follows:

- Central London employment would rise by 1.0%.
- Inner and outer London employment would fall by around 0.5%.
- Household numbers would fall by 0.2% in central London and 0.1% in outer London.
- Household numbers would rise slightly in inner London.
- Higher-income household numbers would increase in central London.

A subsequent study in Edinburgh using the START/DELTA model, which includes responses to both accessibility and environment (Bristow et al. 1999), indicated that a £1.50 charge to enter or leave the city center would increase city center population by 2.2%; an earlier study with a similar model but different parameters (Still et al. 1999) had suggested a 1.8% reduction in city center population and a 3.1% reduction in city center

employment. Both studies suggested that the impacts of changes in accessibility were larger than but opposite in sign to the impacts of changes in environmental quality.

This remains an area of considerable uncertainty on which more evidence is needed.

## Technology

In the past, the operation of point-based road pricing schemes was mostly based on manual toll collection or automatic coin collection machines at tollbooths. The operation required vehicles to slow down and stop at the tollbooth. This system offers a high level of reliability and enforcement. It also involves a simple technology that is widely accepted. However, the system creates serious congestion around the toll collection area. An alternative charging regime is an area-based charging system. The original ALS in Singapore was a showcase of the application of a paper-based system involving a minimum level of technology (Holland and Watson 1978). The downside of the paper-based system is the intensity of manual enforcement. Electronic technology for charging and enforcement is seen as the pathway to the future success of the implementation of road pricing.

Key challenges for technology include reliability, the cost of implementation, and privacy. In addition, well-designed technology can provide for greater flexibility in the range of users and vehicle origins, for more complex charging regimes of the kinds outlined below, and for solutions to equity concerns by permitting varying charges and exemptions for different types of users.

In the past decade there has been rapid development in charging technology in response to the requirements mentioned above. There are two main avenues for the current development of charging technology. The first involves use of the DSRC system. The system is made up of two main types of equipment: roadside equipment (RSE) and in-vehicle units (IVUs) that enable two-way communication using DSRC. The RSE is connected to a computer, which carries out the necessary processing. The arrangement tested in Hong Kong in the 1980s relied on a similar system (Dawson and Catling 1986). However, the Hong Kong system was claimed to violate privacy because of its IVU and back-office technology (Borins 1988). The IVU technology in the early study in Hong Kong was a read-only tag that could signify only the identity of the vehicle to the RSE. The read-only tag could not convey any information such as credits or charges incurred.

The Singapore ERP overcomes this problem by introducing smart card technology for use with IVUs (Menon 2000). Instead of having an account for each vehicle, a smart card contains available funds from which charges are deducted at the charging point. The IVU technology adopted in the Singapore ERP uses a transponder with full two-way communication facilities with a smart card interface that is able to store and process the data. The same system is being tested and implemented widely in Japan as the basis for the future road user charging system (Kumagai 2003).

The DSRC system operates at free-flow level at the charging points. Therefore, it requires a high-level enforcement technology for detecting noncomplying vehicles (Blythe and Burden 1996). The technology currently adopted is automatic number plate recognition (ANPR) and closed-circuit television. ANPR has already been tested and used effectively in many cases such as the Highway 407 system in Toronto, the CityLink scheme in Melbourne, the ERP in Singapore, and recently the ALS in London (Turner 2001). At the charging point, if the vehicle is detected as not having an IVU or smart card or if the card lacks sufficient funds, the number plate will be captured by the ANPR and processed. In London, ANPR cameras at various points inside the charging zone record all vehicles, and each vehicle number plate is compared with the database of registered numbers.

The DSRC can operate at different frequencies. This caused a problem in terms of interoperability of different systems developed by different providers (Clark 2000). An example is the problem in Australia, where the toll systems operated in Sydney and Melbourne are based on different standards and are not compatible (Charles 2001). In the United States the 915-MHz band was chosen as the national standard, while the European Committee for Standardization (CEN) chose 5.8 GHz to avoid the frequency band of the European Global System for Mobile Communications. In Japan, the Association of Radio Industry and Businesses also chose 5.8 GHz as the national standard, but the standard is not compliant with the CEN standard (Guillermo Jordan et al. 2001). To overcome the interoperability problem, the Norwegian government set up a company, AutoPASS, to develop and operate the charging technology for tolling facilities in Norway. The new AutoPASS is consistent with both global ISO standards and European standards (CEN). The new specifications are used in the replacement of four systems in Oslo, Trondheim, Rennfast, and Hvaler. In addition, AutoPASS users can use their cards on almost half of the toll road projects in Norway.

As an alternative to the DSRC-based system, the Global Navigation Satellite System (GNSS) and the General Packet Radio System (GPRS) can be adapted to operate point and distance charging systems (Catling 2000). GNSS uses a satellite-based positioning and navigation system to compute the location of a vehicle in a road network. Currently, the United States and Russia provide the two navigation satellite systems (GPS and GLONASS, respectively). EU's Galileo alternative is due

to be available in 2008. Since the satellite navigation systems provide only one-way communication (from the satellites to the receivers), a cellular phone system is normally used for communication between the vehicle and the control system for the transaction process. For GPRS, the position can be determined by the data connection via the mobile phone network with an always-on connection. The resulting VPS allows a more complex charging regime to be implemented. The system also requires minimum infrastructure on the roads. The fee can be defined on the basis of crossing points, presence in an area, or per unit of time or distance. The fee structure could be stored either at the main control center or in the IVU. A similar system was tested in Hong Kong and was proved to be reliable (Catling 2000). The Swiss and German governments also launched the first large-scale GPS-based project, which will soon be operable and will charge HGVs on the basis of distance traveled (Guillermo Jordan et al. 2001). The key barrier to large-scale implementation, especially in an urban area, is the required level of accuracy of the positioning system. At the moment, the accuracy of the GPS system is 10 to 15 meters, whereas Galileo promises to deliver positioning accuracy down to 4 meters. Despite the potential improved accuracy, there are various blind spots in the road network (e.g., tunnels) where the GNSS may experience problems. This can be overcome by integrating the GNSS with the short-range communication system (e.g., communication with beacons) or a dead-reckoning system (Ochieng 2003).

## Scheme Design and Integrated Strategies

The majority of proposals for road pricing have assumed that charges would be imposed to cross cordons or pass points in the road network. Point-based or cordon charging is a remarkably flexible technique. It can involve single or multiple cordons, screenlines to control orbital movements, and point charges at particularly congested locations, with charges varying by location, direction, and time of day. The early proposals for Hong Kong (Dawson and Brown 1985), those studied in London (Richards et al. 1996), and the current scheme in Singapore (Menon 2000) all exhibit this flexibility.

However, even such complex charging structures have been criticized. It has been argued that they are inflexible since fixed charging points cannot readily be relocated, that they are inequitable because they impose the same charge for short and long journeys, and that they are disruptive because they encourage rerouting to avoid the charge. All of these limitations arise from the discontinuities that point-based charging introduces into the road network. These arguments have led to the alternative suggestion of continuous charging schemes, in which charges are levied on all travel throughout a defined area on the basis of distance traveled, time spent traveling, or perhaps time spent in congestion.

A recent survey of the policies adopted by U.K. city planners indicated that they typically adopted a simple approach by focusing on the city center and any major traffic generators on its fringes. The single cordon would be placed just inside the inner ring road around the center, with crossing points minimized where possible, a uniform charge to cross at all points, and that charge kept low enough to be publicly acceptable (Sumalee 2001).

Conversely, theory tells us that the "first-best" charging regime is one that results in drivers on each link in the road network incurring the marginal cost of travel on that link (Sheffi 1985). Such charges are impracticable and could prove expensive to implement, but they serve as a benchmark for assessing real schemes. The question of where best to locate a single cordon or a given number of charging points is altogether more challenging and has been addressed by relatively few researchers (Hearn and Ramana 1998; Shepherd and Sumalee 2004; Verhoef 2002). One important theoretical study comparing parking charges, cordon charges around centers, continuous charges, and charges limited to selected lanes with free parallel routes suggests that the last of these, which largely reflects HOT lane practice, is by far the least efficient in its impacts on network performance (Small and Yan 2001).

A recent research project has used genetic algorithms to determine optimal locations and charge levels for different patterns of charging points. In an application to Edinburgh, it compared four single cordons largely based on planners' designs, the same cordons with varying charges, an optimally located cordon, and charging limited to 10 isolated points in the network. The planners' cordons varied substantially in their performance, with the best producing more than twice the benefits of the worst. The optimally located cordon was about 25% more effective than the best of those suggested by the planners. Relaxing the requirement for a closed cordon and limiting charges to 10 key points added a further 20% to the benefits, and relaxing the need for uniform charges at all points a further 20% to 60%. Charging at 10 points, with variable charges, proved to be twice as effective as the best planners' cordon with uniform charges (May et al. 2002). While this research raises several other questions, it suggests that there is much to be gained by a more analytical and flexible approach to the location of charging points in urban networks.

Shepherd (2003) investigated the relative performance of cordons, a fuel tax, and a smart card–based approach for Edinburgh within integrated strategies by using the strategic model START. He concluded that small city center cordons can create boundary effects

and increase average trip lengths. Larger cordons can also have boundary effects, though if they are large enough they have little adverse effect on those residing in the area. A simple increase in fuel tax was 84% as effective as the first-best system. This simple system would be easy to implement but would mean adding approximately €1.5 to the price of a liter of fuel. Applying a smart card distance-based system with a minimum and maximum charge level of €1 and €4, respectively, increases the benefits to 96% of first-best results.

A separate strand of research has compared cordon charges with those involving delay. Behavioral research suggests that drivers will be less willing to reroute or reduce their travel in response to time-based charging because the charges are variable and hence uncertain. Conversely, such responses are stronger with distance-based and cordon charges. There is also evidence that variable charges induce greater risk-taking by drivers and hence increase accident risk (Bonsall and Palmer 1997).

The impacts on network performance are very different. Distance-based charging proved the most effective in reducing distance traveled and travel times within the urban areas studied, while delay-based and cordon charging were the least effective. Distance-based and time-based charging were equally effective in reducing the resource costs of travel. However, distance-based charging also had the most extreme impacts on route choice, with significant diversion to the uncharged orbital routes outside the urban area. In all cases the net impact on vehicle kilometers traveled was small, with reductions within the urban area being offset by increases outside. This argues for charges to be imposed over much wider areas than those often envisaged (May and Milne 2000).

Overall, it appears that distance-based charging may prove to be more effective and flexible than point-based charging once the technology is available to implement it.

Road pricing is increasingly being seen, at least in European cities, as part of an integrated strategy in which individual policy instruments complement one another or overcome the barriers to the implementation of other instruments. A recent policy review has suggested that integration can be achieved by reinforcing the benefits, reducing political and financial barriers, and compensating losers. It highlights road pricing as being able, uniquely, to reinforce the benefits of all other types of policy instrument, while at the same time generating income to contribute to their costs. It also notes that other policy instruments can help to reduce its political unacceptability and adverse distributional impacts (May 2004).

An early example of this was the integrated transport study for Edinburgh, which indirectly led to the current road pricing proposals there (May et al. 1992). After extensive analysis, six possible strategies were developed, which involved differing levels of infrastructure investment, road space reallocation, fares, and road pricing, with revenues from the latter hypothecated to finance the former. Two were high-cost strategies involving roundly similar financial outlay, one with and one without road pricing. At the other extreme, two generated sufficient income to pay for the other elements of the strategy with again one involving road pricing and the other not. The third pair involved an intermediate level of finance. Those including road pricing were between 50% and 200% more effective than those without in terms of their net economic benefits; their performance was also much less sensitive to the level of public finance available.

Subsequent research has used optimization techniques to determine the optimal combination of policy instruments in different cities for a given set of policy objectives. An initial study using different transport models in nine European cities found that city center road pricing charges or comprehensive parking charges in the range €1.6 to €5.0 per day were a key element of the optimal strategy in six of the nine cities, and that in five of the six cities the resulting strategy was self-financing over a 30-year period (May et al. 2000). More recent work in four cities, using the same transport model for each, has demonstrated that city center road pricing, with peak charges in the range €1.9 to €7.9 per day, is part of the optimal strategy, together with public transport fare reductions and frequency increases (Emberger et al. 2003).

## Conclusions

Martin Wachs (2005) comments that "road pricing is not quite yet within the mainstream of transport policy options, but . . . more progress has been made in that direction in the last decade than had been made in the preceding 70 years."

That assessment is clearly borne out in experience elsewhere in the world. The past decade has seen the introduction of electronic road pricing in Singapore and congestion charging in London; the establishment of toll cordons in Norway; and a commitment to distance-based charges in Germany and the United Kingdom, at least for HGVs. While elsewhere it has repeated the pattern of proposals for and rejection of urban road pricing of previous decades, we can at least claim that that activity has become more intense, particularly in the United Kingdom, Italy, Sweden, the Netherlands, Japan, and Hong Kong.

Where proposals fail, the barriers to progress remain largely the same: lack of political commitment reinforced by limited public acceptance and concerns about equity, economic impacts, and, to a lesser extent, technology.

However, we have also made significant progress in research into these issues in the past decade. We now have a much fuller understanding of the factors influencing acceptability. We have identified the key dimensions of equity and understand better the scale of impact on different groups. Technological developments have been substantial and offer new solutions to earlier concerns. In addition, recent research into optimal scheme design offers ways of intensifying the benefits of road pricing once introduced. It is only in the area of economic impacts that significant uncertainties remain, and it appears unlikely that a much greater understanding can be obtained in the absence of empirical research.

The potential for a significant breakthrough in the next decade is greater than it has ever been, but much will depend on the political commitment of local and national decision makers. London is particularly important in this regard, because it offers the first demonstration of successful application in a city to which others can relate. It also promises, over the next 2 years, precisely the detailed empirical evidence called for in *Curbing Gridlock* (Transportation Research Board and Commission on Behavioral and Social Sciences and Education 1994). London, of course, is not typical of most other cities that are considering road pricing; even before congestion charging only 15% of central London commuters traveled by car. But the detailed empirical evidence on user and system responses should allow others to assess more reliably what the impacts would be in their own cities.

London also offers evidence for political analysts on the processes that enable such a complex scheme to be implemented successfully. Central government played the key initial role in establishing the position of the mayor and providing him with the necessary enabling legislation. The appointment of a strong, visionary leader with such powers then enabled the scheme to be implemented, despite the loss of confidence and commitment at the central government level. Paradoxically, the most powerful ally of the left-of-center mayor proved to be the business community rather than the socialist government.

As in London, much will depend in the next decade on political will at both the national and the local levels. European politicians are almost certainly ahead of those in North America in accepting that we cannot build our way out of our transport problems. But they remain cautious about policies that are likely to be unattractive in the short term and may take much of a term of office to implement. National governments need to assist by providing enabling legislation and consistent policy support. Local governments will succeed where they can find visionary leaders who are supported by committed and creative professionals.

## References

### Abbreviations

| | |
|---|---|
| DETR | Department of the Environment, Transport, and the Regions |
| PATS | Pricing Acceptability in the Transport Sector |


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# Committee Member Biographical Information

**Steve Heminger,** *Chair*, is Executive Director of the Metropolitan Transportation Commission (MTC), the regional transportation planning and finance agency for the San Francisco Bay Area. MTC allocates roughly $1 billion per year in funding for the operation, maintenance, and expansion of the Bay Area's road and transit networks. MTC also functions as the region's Service Authority for Freeways and Expressways and has served as the Bay Area Toll Authority responsible for administering the base $1 toll on the state-owned bridges. Before joining MTC in 1993, he was Vice President of Transportation for the Bay Area Council, a regional public policy group. He also has served as a staff assistant in the California State Legislature and the U.S. Congress. He received a master of arts degree from the University of Chicago and a bachelor of arts degree from Georgetown University.

Mr. Heminger is prominent in the area of road pricing. He led the effort in the San Francisco Bay Area that received the first congestion pricing demonstration grant from the Federal Highway Administration. He also served on the National Research Council committee on congestion pricing that produced *Special Report 242: Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion* (1994).

**Robert D. Bullard** is the Ware Professor of Sociology and Director of the Environmental Justice Resource Center at Clark Atlanta University. He is the nation's leading expert on environmental justice and transportation equity. Dr. Bullard is the author of 11 books that address sustainable development, environmental justice, urban land use, industrial facility permitting, community reinvestment, housing, transportation, and smart growth. His book *Dumping in Dixie: Race, Class and Environmental Quality* (Westview Press, 2000) is a standard text in the environmental justice field. His other books include *In Search of the New South* (University of Alabama Press, 1991), *Confronting Environmental Racism: Voices from the Grassroots* (South End Press, 1993), *People of Color Environmental Groups Directory 2000* (Charles Stewart Mott Foundation, 2000), and *Unequal Protection: Environmental Justice and Communities of Color* (Sierra Club Books, 1996). He coedited *Residential Apartheid: The American Legacy* (University of California at Los Angeles Center for African American Studies Publications, 1994); *Just Transportation: Dismantling Race and Class Barriers to Mobility* (New Society Publishers, 1997); and *Sprawl City: Race, Politics and Planning in Atlanta* (Island Press, 2000). His most recent book is titled *Just Sustainabilities: Development.*

**Kenneth J. Button** has been Professor of Public Policy and Director of the Center for Transportation Policy and Operations in the School of Public Policy, George Mason University, Fairfax, Virginia, since 1997. From 1994 to 1996 he was Conseiller in the Advisory Unit to the Secretary General of the Organisation for Economic Cooperation and Development (OECD), Paris, where he headed work on international aviation policy. He was at that time on leave from being concurrently Professor of Applied Economics and Transport at Loughborough University, United Kingdom, and VSB Visiting Professor of Transport and the Environment at the Tinbergen Insti-

tute, Amsterdam, Netherlands. He was also at the time Director of the Centre for Research in Economics and Finance at Loughborough University. He was the Special Advisor to the U.K. House of Commons Transport Committee between 1993 and 1994. In 1990 he was full-time Consultant to the OECD Environmental Directorate.

Dr. Button's academic training is in the fields of economics, econometrics, and transportation planning. He has published or has in press some 80 books and more than 400 papers in leading academic journals. He has given written and oral evidence to transportation committees of the U.S. Congress and to both the U.K. House of Lords and House of Commons Transport Committees. His work on road pricing includes jointly editing *Road Pricing, Traffic Congestion and the Environment* (Edward Elgar publishing), serving on the Chartered Institute of Transport (CIT) working party on *Paying for Progress: A Report on Congestion and Road Pricing*, and chairing the CIT working party on *Paying for Better Motorways*. In addition, he has published articles on road pricing as chapters in numerous books and in such journals as *Transportation Research*; *Transportation Research Record: Journal of the Transportation Research Board*; *International Journal of Transport Economics*; *Logistics and Transportation Review*; *Transport Reviews*; and *Transportation Planning and Technology*. Dr. Button received a B.A. degree from the University of East Anglia, an M.A. from the University of Leeds, and a Ph.D. from the University of Loughborough.

**Damian J. Kulash** is President and CEO of the Eno Transportation Foundation, Inc., Washington, D.C. He has 30 years of experience in managing transportation organizations. He has been extensively involved in transportation policy analysis and has managed many multidisciplinary, multiperspective teams to extract action plans in complex, difficult situations. He has successfully brought industrial and government leaders to work together and has forged new working arrangements between state and federal agencies. As Executive Director of the $153 million Strategic Highway Research Program, Mr. Kulash created and managed scores of diverse advisory committees to guide the program toward useful products and to work with federal, state, and industry organizations to put results into practice. As President and CEO of the Eno Transportation Foundation, he has established a series of forums dealing with cutting-edge issues affecting all modes of transportation and their compatibility with other areas of national concern. They include activities addressing the economic returns on transportation investment, coordination of intermodal freight operations in Europe and the United States, and development of a U.S. transportation strategy compatible with national global climate change objectives.

**Kathleen F. Marvaso** is Managing Director, AAA Government Relations, Washington, D.C. In this capacity she directs all federal and state legislative activities for the 45 million member association, focusing on a full range of safety and mobility issues affecting travelers. Since 1993, Ms. Marvaso has been instrumental in developing strategies to help the association achieve its public service goals, improve mobility, and enhance the safety of the traveling public. In recent years she has guided the 80-club federation's efforts to enact graduated driver licensing laws in every state and has directed the association's advocacy work on issues including truck safety, highway maintenance, design and funding, child passenger safety, and clean air.

Before joining AAA, Ms. Marvaso worked as a legislative assistant for Congressman Bill Nelson, now one of Florida's two senators, and managed campaign operations for Mr. Nelson's 1990 bid for governor. A journalism graduate of the University of Florida at Gainesville, she earned a master's degree in business administration from George Mason University in Virginia.

**Anthony D. May** has more than 35 years of experience in transport planning and traffic engineering. He has been a Professor at the University of Leeds, United Kingdom, since 1977, and he has served as Head of the Department of Civil Engineering, Dean of the Faculty of Engineering, and Pro-Vice Chancellor for Research. He is currently Director of the Institute for Transport Studies. Between 1985 and 2001 he maintained a link between research and teaching at Leeds and practical experience in consultancy with MVA Ltd., for which he was Director of Transport Policy. Before 1977 he spent a number of years with the Greater London Council, where he was responsible for policy on highways, traffic management, and transport-related land use planning for the capital and managed major studies on traffic restraint, parking policy, and motorway traffic control.

While at Leeds, he has been awarded more than 80 research grants and contracts by the Engineering and Physical Sciences and Economic and Social Science Research Councils, the European Community, the Rees Jeffreys Road Fund, and several local authorities. Among the studies conducted have been those for the transport problems of inner-city firms, techniques for monitoring travel, development of dynamic route guidance, the management of congestion at signalized junctions, the most appropriate structure for the organization of transport functions in the U.K. conurbations, the design and assessment of road pricing strategies, the development of trip planning systems and awareness campaigns, the combined performance of transport and land use strategies, the impact of integrated transport strategies and their contribution to

environmental policy, and the development of guidance on sustainable urban transport and land use policy.

Dr. May has been a specialist adviser to the House of Commons Transport Committee and the House of Lords Select Committee on Science and Technology and a consultant to OECD, the World Bank, the Transportation Research Board, the Singapore Land Transport Authority, the New Zealand Ministry of Transport, and the Thailand Commission for the Management of Land Transport.

**Servando M. Parapar** was selected by the Miami–Dade Expressway Authority (MDX) board to serve as its first Executive Director in 1996. Mr. Parapar's first priority was to negotiate the transfer of the Miami–Dade County tollway system, which was accomplished in December 1996. Since then, under his leadership and guidance, MDX has put together a $2.75 billion master transportation plan with the overriding objective of creating an integrated system that provides a seamless and balanced movement of traffic. The current MDX 5-year work program is estimated at $796 million. Mr. Parapar directed the strategic alliance with the Florida Department of Transportation that has led to the successful implementation of SunPass, a statewide electronic toll collection system, at MDX facilities. Under his guidance MDX has utilized design–build contracts to complete three roadway construction projects in record time. Mr. Parapar is also leading Phase I of the SR-836 corridor reconstruction, one of the major roadways in Miami–Dade County.

Mr. Parapar serves on the boards of directors of the International Bridge, Tunnel, and Turnpike Association and the Intelligent Transportation Society of Florida. He was born in Havana, Cuba. A U.S. citizen, he holds a bachelor's degree in architectural engineering from the University of Miami and a master's degree in civil engineering from the University of Florida.

**Robert W. Poole, Jr.,** is founder of the Reason Foundation and a nationally known expert on privatization and transportation policy. In 1978 Mr. Poole launched the Reason Foundation, a national public policy research organization. He began researching privatization of government functions in the 1970s, and his book *Cutting Back City Hall* (Universe Books, 1980) was the first book-length examination of the subject. He advised the White House Office of Policy Development on privatization during the Reagan years and testified before the President's Commission on Privatization in 1987. During the first Bush administration, he worked with the Vice President's Competitiveness Council and the White House Counsel to help develop an executive order on infrastructure privatization. In 1992 he served as a board member of the Vice President's Space Policy Advisory Board.

Mr. Poole was one of the first to propose privatization of the air traffic control system, and his work in this field has helped shape current proposals for an air traffic control corporation. His 1988 policy paper on private toll roads directly inspired California's landmark legislation on the subject (since emulated in 15 other states); he served 18 months on the Privatization Advisory Steering Committee of the California Department of Transportation helping to implement the measure. In 1995 he served as a member of California's commission on transportation investment. Mr. Poole has also helped launch national debates on airport privatization and on congestion pricing for urban freeways.

Mr. Poole received bachelor's and master's degrees in engineering from the Massachusetts Institute of Technology.

**Edward J. Regan III** is Senior Vice President of Wilbur Smith Associates (1990 to present). He is responsible for the oversight and management of the TFT Group, a 45-person division dedicated to providing professional services to the toll industry worldwide. Mr. Regan is a recognized expert in toll facility studies and finance. Under his leadership, traffic and revenue studies performed by the TFT Group have been used in support of more than $50 billion in toll facility finance. He has also been heavily involved in the development and analysis of innovative value pricing programs for various toll facilities. His technical specialties include senior project management, transportation planning, road pricing studies, traffic operations, toll feasibility studies, traffic and revenue studies, strategic planning, toll collection/automatic vehicle identification system design, and toll plaza operations. He has overseen projects in the United States, Canada, and Australia.

**Martin Wachs** is Director of the Institute of Transportation Studies at the University of California, Berkeley, where he also holds faculty appointments as Professor of City and Regional Planning and as Carlson Distinguished Professor of Civil and Environmental Engineering. Until 1996 he was Professor of Urban Planning and Director of the Institute of Transportation Studies at the University of California at Los Angeles, where he had been a member of the faculty since 1971 and where he served three terms as Head of the Urban Planning Program. The Institute of Transportation Studies at Berkeley is one of the largest academic transportation research centers in the United States. It has approximately 200 employees and an annual budget of $40 million.

Dr. Wachs holds a bachelor's degree in civil engineering from the City University of New York and M.S. and Ph.D. degrees in transportation planning from the Civil Engineering Department at Northwestern University. He is the author or editor of four books and has written

more than 130 published articles on transportation planning and policy on such topics as the transportation needs of elderly and handicapped people, fare and subsidy policies in urban transportation, the problem of crime in public transit systems, and methods for the evaluation of alternative transportation projects. He has also done historical studies of the relationship between transportation investments and urban form in the early part of the 20th century and on ethics in planning and forecasting. Recently, his writings have dealt with transportation finance and the relationship between transportation, air quality, and land use.

Dr. Wachs served as Chairman of the Executive Committee of the Transportation Research Board during 2000, and he recently completed a term as a member of the California Commission on Transportation Investment, to which he was appointed by Governor Pete Wilson. He is currently a member of the Advisory Committee on Research and Development for the California Department of Transportation and recently completed his term as the first Chair of the Advisory Panel for the Travel Model Improvement Program of the U.S. Department of Transportation. He chairs the Subcommittee on Planning and Policy Review of the Transportation Research Board's Executive Committee.

Professor Wachs is a Fellow of the American Institute of Certified Planners, a National Associate of the National Academy of Sciences, a Member of the American Society of Civil Engineers, and a member of the Institute of Transportation Engineers.

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