Proceedings of the 2010 Land Policy Conference

CLIMATE CHANGE AND LAND POLICIES

Edited by Gregory K. Ingram and Yu-Hung Hong

Climate Change and Land Policies

Edited by

Gregory K. Ingram and Yu-Hung Hong

LINCOLN INSTITUTE
OF LAND POLICY
CAMBRIDGE, MASSACHUSETTS

Library of Congress Cataloging-in-Publication Data

Climate change and land policies /
edited by Gregory K. Ingram and Yu-Hung Hong.
p. cm.
Conference proceedings.
ISBN 978-1-55844-217-7
1. Land use, Urban—Congresses. 2. Climatic changes—Government policy—Congresses. 3. Climatic changes—Environmental aspects—Congresses. I. Ingram, Gregory K. II. Hong, Yu-Hung.
HD1391.C64 2011
333.73'13—dc22 2011003415

Designed by Vern Associates

Composed in Sabon by Achorn International in Bolton, Massachusetts.
Printed and bound by Puritan Press Inc., in Hollis, New Hampshire.
♻ The paper is Rolland Enviro100, an acid-free, 100 percent PCW recycled sheet.

MANUFACTURED IN THE UNITED STATES OF AMERICA

CONTENTS

10

Congestion Pricing: An Overview of Experience and Impacts

Kiran Bhatt

Traffic congestion is a major problem facing large urban areas in the United States and around the world. Congestion leads to delays in both passenger and freight movement. It causes wasted fuel consumption, increased vehicle emissions, and increased costs to highway users. It affects economic productivity and, possibly, land use. In some of the world's largest cities, the so-called rush hour can last much of the day, and travelers are more likely to be stuck in gridlock than to be moving in free-flowing traffic. Demands on road systems are already overwhelming available capacity, and forecasts warn of worsening conditions in the future. The costs associated with traffic delays and the associated wasted fuel in the United States were estimated to total $78 billion in 2005 (TTI 2007). Transportation agencies have been seeking new and better ways of dealing with congestion problems.

Traditional transportation strategies are becoming increasingly ineffective, since they often fail to link the decision to travel on a congested road with the full costs associated with that travel. Congestion pricing provides such a link. Furthermore, congestion pricing provides incentives for more efficient use of road capacity and generates revenues. In most U.S. and international pricing projects, revenues have been used to cover operating and enforcement costs, finance highway infrastructure, and enhance transit alternatives. These revenues have supported transportation improvements and generated benefits for travelers that may otherwise not have been materialized.

U.S. Experience with Congestion Pricing

MAJOR U.S. CONGESTION PRICING PROJECTS

Over the past 20 years, more than 50 congestion pricing projects have been studied in detail, and more than 20 have become operational. Most of the projects have overcome early implementation hurdles and met their objectives. By influencing travel behavior, pricing projects have prevented congestion from recurring on priced lanes, reduced congestion on toll facilities, and improved utilization of highway capacity. Yet issues remain with regard to public attitudes toward pricing, equity concerns, and long-term impacts such as land use and productivity.

The range of project types that either have been implemented or are under investigation in the United States include congestion pricing on one or more highway lanes, either existing high-occupancy vehicle (HOV) lanes or new express lanes; conversion of fixed tolls to variable tolls on existing toll or toll-free facilities; and broader applications of congestion pricing on an areawide basis. Other pricing proposals have been designed to convert particular driving costs from a fixed to a variable basis or to promote differential parking pricing (KTA 2008b).

HOT Lanes The most common application of congestion pricing in the United States involves the conversion of existing HOV lanes into HOT (high-occupancy toll) lanes, where vehicles not meeting normal HOV requirements are allowed to buy into the lanes by paying a toll varying by level of congestion or demand. An important rationale for HOT lane conversions is that HOV lanes have been underutilized. Electronic tolling is used to ensure high-speed access to the lanes, and tolls are set to maintain the free flow of traffic. HOT lanes provide travelers with a new array of choices in the face of congestion: drivers can continue to use the untolled congested lanes; they can choose to pay a toll to gain access to the high-speed lanes; or they can meet minimum occupancy requirements and use the high-speed lanes for free. Some major HOT lane projects include I-15 in San Diego, I-10 and U.S. 290 in Houston, I-394 in Minneapolis, I-25/U.S. 36 in Denver, State Route 167 in Seattle, and I-95 Express Lanes in Miami.

New Priced Express Lanes The key characteristic of this project type is the provision of new highway capacity along with the initiation of highway pricing. The new capacity may be in the form of new through lanes, bypass lanes around a congested point, or a new bridge or tunnel. Users must pay a variable toll to gain access to the new capacity, but preference (e.g., free or reduced-toll access) may be provided for HOVs. As with other pricing projects, electronic tolling is needed to ensure the effectiveness of time-of-day tolling. Newly constructed express lanes with variable tolls have been implemented in only one location, State Route 91 in Orange County, California, but other new express

lane projects are under development in Baltimore, San Diego, Houston, and Dallas–Fort Worth.

Congestion Pricing on Existing Toll Facilities The introduction of variable tolls on facilities that currently have flat tolls is another important form of congestion pricing. The use of variable time-of-day tolls is intended to encourage travelers to shift to off-peak times, alternative transport modes, or alternative routes. Examples include Lee County, Florida's off-peak toll discount program; time-of-day tolls on the New Jersey Turnpike; the variable toll program of the Port Authority of New York and New Jersey (PANYNJ); and the Illinois Tollway's truck toll discount.

OTHER U.S. CONGESTION PRICING INITIATIVES

A number of other pricing initiatives either have been implemented or are under consideration, including zonal and regionwide congestion pricing, programs to convert fixed automobile costs to variable costs, and strategies to make automobile ownership and parking costs more apparent through car-sharing or parking pricing programs.

The most ambitious of these options is zonal and regionwide congestion pricing, in which pricing is applied at several locations within a city or region, including new or existing highways, lanes, or other facilities. In some cases, regionwide programs to promote carpooling or improve transit service also may be incorporated. Such broad applications of pricing have been adopted in other parts of the world, but have only reached the feasibility study phase in the United States.

Zonal Pricing Officials in New York City considered a zonal pricing scheme similar to that adopted in London (described later in this chapter). The priced zone would have encompassed much of the island of Manhattan below 60th Street, with vehicles being charged $8 via E-ZPass for entering this zone. Anticipated net annual revenues of about $500 million were to be used to improve and expand mass transit. The congestion pricing period was to be 12 hours (6:00 a.m. to 6:00 p.m.). The plan was expected to reduce vehicle miles of travel (VMT) by 6.8 percent. It was also projected to reduce traffic across the city, by 30 percent inside the priced zone and 20 percent outside the zone (NY State 2008).

Although the plan generated strong feelings both for and against it, overall press and public reaction was positive. The plan was supported by the mayor and the governor; a vast coalition of civic, business, and environmental leaders; and major newspapers. Public support was more than 65 percent, and the city council approved it. However, opposition came from the four boroughs outside Manhattan and the state senate, where it was not allowed to come up for vote. Eventually, the proposal failed largely because, though it was perceived as beneficial to

society at large, it was not seen as clearly benefiting individual drivers (Schaller 2010). Although this proposal failed to win approval, advocates of congestion pricing in New York City believe that a pricing program will reemerge in the not-too-distant future.

Regionwide Pricing Regionwide congestion pricing approaches have been under consideration in California (San Francisco area), Maryland, and Virginia for several years. A study of regionwide options in Maryland, with possible pilot projects identified in several locations, including HOT lane options on interstate routes, has been completed. In 2005 an agreement was signed for new express toll lanes on the I-95/JFK Expressway outside Baltimore (expected to be completed in 2011). A study is currently under way to extend those lanes an additional 10 miles. In 2007 the possibility of adding priced lanes on I-270 and I-495 was explored. These lanes might connect to the variably priced Inter-County Connector (ICC) in Prince Georges and Montgomery counties (now under construction) and to planned I-495 HOT lanes in Virginia.

In addition to these efforts, a National Capital Region Transportation Planning Board (TPB) study was launched in 2005 to examine the feasibility of a regionwide network of priced lanes. The scope included HOT lanes along the Capital Beltway in Virginia, six new priced lanes along the new ICC in Maryland, and HOV lanes converted to HOT lanes on the I-95/I-395 corridor in northern Virginia. The TPB also evaluated alternative scenarios for networks of variably priced highway facilities in the metropolitan Washington region. Analysis included assessments of demand, revenues, costs, viability of transit operations, and land use and equity impacts. The pricing would result in "free-flow" road conditions. Also, while capacity addition would result in an overall increase in regional VMT, the growth in VMT would decline as pricing was applied to a greater proportion of existing lanes and as lane additions were curtailed. Applying variable pricing to existing lanes would generate revenues significantly in excess of costs. The study also found that change in accessibility to jobs and housing would be fairly evenly distributed across various population subgroups (TPB 2007).

Alternative Fees Projects designed to convert some of the fixed costs of owning and operating a vehicle to variable costs either are being studied or have been undertaken on an experimental basis. The Oregon Department of Transportation has studied and conducted a field test of the feasibility of replacing the fuel tax with a mileage-based fee, including using variable time-of-day fees in congested areas at peak travel times. The Puget Sound Regional Council in Washington State conducted a field test examining the practicality and travel effects of tolls based on distance, time of day, and location. The Minnesota Department of Transportation evaluated the impacts of calculating lease costs of cars and insurance premiums on a per-mile basis. In Atlanta, test households were used to examine responses to mileage-based insurance charges. Atlanta

has plans for further evaluations in which fees vary by time and location. These initial efforts have provided some evidence that mileage-based fees do influence driver behavior (KTA 2008b).

KEY FINDINGS FROM U.S. CONGESTION PRICING PROJECTS

Operational congestion pricing projects are providing valuable information about impacts of these innovative concepts (KTA 2008b).

Travel and Traffic Impacts With few exceptions, variable pricing programs have met their principal travel and traffic objectives. These programs have demonstrated that pricing can have a number of effects on driver behavior and traffic volumes, including changes in times trips are made, routes taken, and modes of travel used; willingness to pay for faster travel times by using toll lanes; reductions in peak-period traffic volume; and more efficient use of highway capacity. In particular:

- HOT lane conversions have made better use of underutilized HOV lanes, kept lanes congestion-free, and not slowed or dissuaded HOV lane users. Also, there is some, albeit inconclusive, evidence that HOT lane conversions have brought relief to adjoining mixed-flow lanes by attracting some traffic away from them (SANDAG 2001).
- New variably priced express lanes render much higher throughput at significantly higher speeds than adjoining general-purpose lanes, and they reduce congestion on the overall facility. Variable tolls have led to more efficient facility use, postponed the need for capacity improvements, and preserved or increased revenues (KTA 2008b).

Regionwide pricing initiatives are mostly in the preimplementation stage, but planning studies suggest they will mirror the positive experiences of HOT lane conversions and new priced express lanes, and they may be more effective than the sum of individual projects. Projects making fixed driving costs variable, while tested only in experimental conditions, have reduced weekday peak-period and/or weekend travel by encouraging shifts in travel times and modes.

Costs and Revenues Project revenues have been used to cover operating and enforcement costs, finance additional highway infrastructure, and improve transit alternatives. In most projects reviewed, the revenues generated by pricing have supported transportation improvements and generated benefits for travelers that may otherwise not have been materialized.

For HOT lane conversions, revenues generally support operations and in some cases additional transit service, although one smaller program did not raise sufficient revenues to cover all operation costs, and a long-standing program is adding new fees to cope with declining use and revenues caused by the opening of a new facility nearby. It may be difficult to cover the initial capital costs with

toll revenues, especially where conversion requires large capital outlays or where a relatively large number of vehicles travel for free.

The one well-evaluated new express lane project (State Route 91 Express Lanes in Orange County, California) shows that a privately owned and operated tollway can be financially viable and bring savings to the public sector. Financial information on new variable pricing on existing toll facilities suggests that revenues can meet targets and may delay costly capital improvements. The introduction of variable pricing on existing toll facilities has been relatively inexpensive, since infrastructure and operations typically are already in place. Consequently, revenues have exceeded the costs of these projects.

Although regionwide pricing initiatives are too new for us to draw confident financial conclusions, one study suggests that financial feasibility is highly dependent on the capital costs of new facilities. Experiments with variable driver costs also are too limited for confident conclusions, although observed user responses in experimental demonstrations suggest that these strategies might be able to more than cover costs.

Equity Since the inception of the federal Value Pricing Pilot Program in 1991 making federal grant money available to U.S. localities for implementing congestion pricing demonstrations, equity has been a key program focus, with particular attention given to mitigating possible adverse effects of projects on low-income drivers. Project experience has shown, however, that the perception of unfairness may be overblown, particularly in the most common projects funded under the early phases of the program.

Equity issues do arise in planning and implementation across several pricing categories, but they have rarely led to project termination. Equity evaluations, though limited in scope, have found some differences in incomes of facility users, but these differences are not dramatic.

Questions about catering to the rich have arisen during the planning of some HOT lane conversions, but such concerns usually have not been sufficient to halt any projects. They also tend to diminish among users and the public as operations get under way. User surveys reveal that although higher-income travelers use such facilities somewhat more than other income groups, people across a wide range of incomes use them as well (KTA 2008b).

Although new expressways with variable pricing are limited in number, surveys do reveal some differences in use based on income, but few differences in reactions to projects have been found. In one case, use increased over time for all modes of transport across all incomes (KTA 2008b). A planned expansion project found strong support with few differences in views about fairness based on ethnicity or income.

For congestion pricing on existing tollways, equity concerns in regard to income have not blocked programs, but questions have been raised about fairness to those with inflexible work schedules and businesses that cannot respond

to increased prices in the short run. User surveys have been limited, but one case suggests that higher-income travelers may be more likely to own transponders both before and after price changes.

The regionwide pricing category also shows a variation in definitions and evaluation approaches to address equity. One project, the regional network of value-priced lanes in Virginia, accounted for impacts across ethnic and income groups by estimating jobs within a travel-time perimeter compared to the general population.

Environment Environmental evaluations are scarce across categories of pricing projects. A few findings suggest possible positive impacts, but more evaluation is needed.

One HOT lane conversion, San Diego I-15 FasTrak, resulted in an increase in emissions, but a comparison corridor in San Diego (I-8) showed an even bigger increase. Another project, Minnesota I-394, measured carbon monoxide emissions and noise, finding no significant changes compared to preproject levels.

One case of congestion pricing on tollways, the New Jersey Turnpike, attempted a detailed assessment of air quality impacts, but found that existing forecasting models were inadequate for the job. Regionwide pricing initiatives will require some VMT and air quality assessments, but current evaluation is via models, and results are still very preliminary.

Field tests of variable driver costs found that mileage and congestion charges can reduce travel in priced vehicles. However, air quality effects depend on shifting to alternative modes of transportation and unpriced household vehicles, a complexity requiring further study.

Outreach/Acceptance Public opinion is perhaps the most critical determinant of the prospect for successful congestion pricing implementation. For this reason, efforts to implement variable pricing projects have given much attention to measuring and understanding public opinion about value pricing and to shaping informational programs to address concerns expressed in public opinion surveys, focus groups, and stakeholder interviews.

Outreach efforts as part of initial feasibility studies often encounter neutral or skeptical reactions, and even outright resistance, but these responses tend to be followed by acceptance as projects get under way. Thus, early and continuing outreach is expected to be most effective in winning over the public. The support of a key stakeholder who is able to influence public opinion also seems to be crucial for successful implementation.

HOT lane conversions entail extensive outreach efforts, often leading to revised or dropped plans, though early resistance can turn to acceptance with responsive service. The support of elected officials, advocacy groups, and community leaders appears to be vital, and winning public support may take months if not years of effort.

New variably priced highway facilities also require outreach. While public support is generally favorable, the public may not understand what expenditures congestion pricing revenues will support, and public opinion can deteriorate if private sector operations are seen as monopolistic and inflexible.

Similarly, variable pricing on existing toll facilities must be accompanied by considerable outreach. Such efforts led to successful implementation in one case (PANYNJ's Hudson River crossings) but not another (Pennsylvania Turnpike). In the former project, the positions of opponents and supporters remained the same before and after implementation, showing the importance of continuing efforts to maintain an acceptance threshold.

Outreach is part of all ongoing regionwide pricing initiatives, but with results yet to be documented. Results of variable cost field tests suggest that initial concerns about security and technology can be assuaged after sufficient time and experience. The parking cash out program in Seattle met with stiff resistance that could not be overcome, underscoring how this category of pricing is highly dependent on the mode of transportation, parking options, and economic environment in which it is attempted.

CONCLUSIONS BASED ON U.S. CONGESTION PRICING EXPERIENCE

Pricing projects in the United States are breaking new ground and providing important lessons for those interested in exploring the use of market-based approaches in responding to traffic congestion problems. Observations from projects implemented to date reveal that travelers are willing to pay for improvements in transportation service and that pricing can lead to more efficient use of existing highway facilities. People respond to price signals when making transportation decisions, just as they do in other aspects of their economic lives, and those responses can help diminish congestion and support alternatives to solo driving. State, regional, and local authorities are showing increasing interest in variable pricing approaches to address traffic congestion, funding shortfalls, and related problems. Pricing has come to be viewed as an innovative way of coping with recurring congestion problems and as an effective complement to existing transportation improvement programs.

Effects of Pricing Pricing does reduce congestion and can increase throughput. It also can be an important source of revenue for transportation projects. Equity issues are ever present, however, and are likely to persist, even though project impact studies have shown no great disparity in use across income groups, and equity impacts have not been an impediment to implementation. Congestion pricing can have positive environmental and energy benefits where it affects a significant number of trips.

Feasibility and Implementation of Pricing The nature of policy and institutional issues that arise during the implementation and operation of congestion pricing projects depends on the category of projects involved. Strategies that

affect large proportions of drivers, cover large areas, produce large revenues, and potentially result in major new administrative and enforcement methods are likely to generate the most complex policy and institutional concerns.

Public and political acceptance is the most critical determinant of successful implementation. Thus, much attention must be devoted to measuring and understanding public opinion. Cultivation of public support will require carefully crafted outreach programs based on opinion surveys, focus groups, and stakeholder interviews.

The technology for pricing and enforcement has generally been reliable and effective, even with complex pricing policies. Some aspects, such as privacy safeguards and occupancy detection, require further testing and development, however.

Evaluation programs have dealt well with traffic impacts, project operations, and public and customer reactions. They have paid less attention to equity and environmental impacts and long-term land use and productivity implications.

International Experience with Congestion Pricing

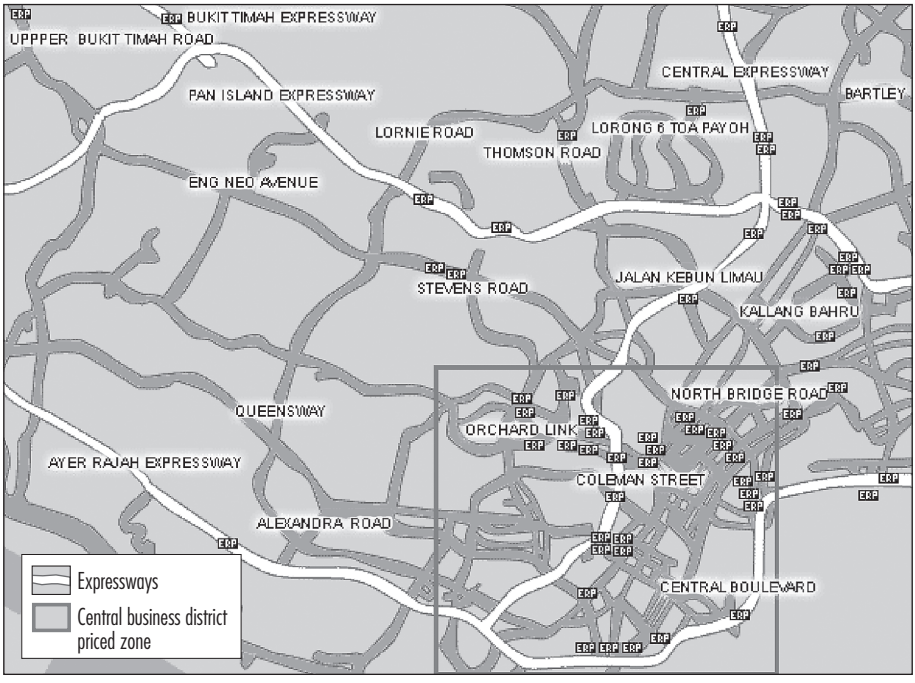
Whereas the congestion pricing programs implemented in the United States have focused largely on single facilities or lanes, programs in other countries more commonly involve zonal or regionwide applications (AECOM Consult 2006; KTA 2008a; TRB 2005). Since the initial implementation of areawide congestion pricing in Singapore in 1975, more than 20 pricing projects have become operational outside the United States. Many of these projects involve fees for entering or traveling within a congested zone. Some focus on charging vehicles for entering entire urban regions, while others use congestion pricing on expressway networks. Major pricing projects have been implemented in the United Kingdom, France, Norway, Sweden, Germany, Switzerland, Singapore, and Australia. In addition, congestion pricing studies have been conducted in nearly all European Union countries, as well as in Asia, Canada, Australia, and New Zealand. As in the United States, international projects are constantly breaking new ground and providing important lessons about the use of pricing to combat traffic congestion.

THREE BROAD APPROACHES TO CONGESTION PRICING

Three projects highlight some of the broader approaches to congestion pricing that have been adopted internationally.

Singapore Since the inception of Singapore's congestion pricing program in 1975, many reports have described the pattern and evolution of pricing in that island nation. Most important in this overview is the advancement made in the program, which has grown from the rather simple, manually controlled Area Licensing Scheme (ALS) to the fully automated Electronic Road Pricing (ERP) system. ERP is both broader in geographic scope and more sophisticated in

Figure 10.1
Singapore Electronic Road Pricing (ERP), 2005



Source: Land Transport Authority, Singapore (2008).

terms of controlling congestion on major roads, with fees that vary by location, day of the week, and time of day (see figure 10.1). Charges are adjusted every calendar quarter to maintain the free flow of traffic within the central business district and to keep speeds at desired levels on principal expressways and arterials. The operating authority also can expand the number of charging points over time as traffic conditions warrant.

To make this system work, every vehicle traveling through a pricing location is required to have an in-vehicle transponder, also called an in-vehicle unit (IU), installed on its dashboard. A smart card with a stored value fits in the IU. Overhead gantries at the pricing location verify the functioning of the IU, identify the associated vehicle type, and deduct the appropriate charge. The IU has a visual display and an audio signal to inform the driver of deducted charges or a low smart card balance. Smart cards are issued by a consortium of banks, and drivers can add to the stored value at banks and ATMs. Smart cards can be used for many purchases at retail establishments as well.

The gantry readers also detect violations and malfunctions. In the case of a violation, cameras capture the vehicle's license plate, and a citation is issued by mail. Vehicles without an IU can be assessed a fine of S$70,[1] while vehicles with insufficient funds on a smart card must pay an administrative fee of S$8.50. Violation rates have been about 0.3 percent.

ERP allows vehicle identification and charging to take place at full highway speeds (up to 120 kilometers per hour, or kph) in a multilane open system without tollbooths or lane restrictions. Approximately 300,000 transactions are processed each day.

Revenues from the pricing system average S$80 million per year, while annual operating costs amount to S$16 million. The capital costs of ERP totaled S$197 million.

The effects of Singapore's congestion pricing system on traffic flow have been quite significant, particularly when combined with policies designed to raise the costs of owning an automobile and to use pricing revenues to improve public transportation alternatives. Average speeds are maintained at 20–30 kph on city roads and 45–65 kph on expressways. According to the system's manager, the pricing scheme 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 (Electronic Road Pricing system) stops operations" (Menon 2005, 36).

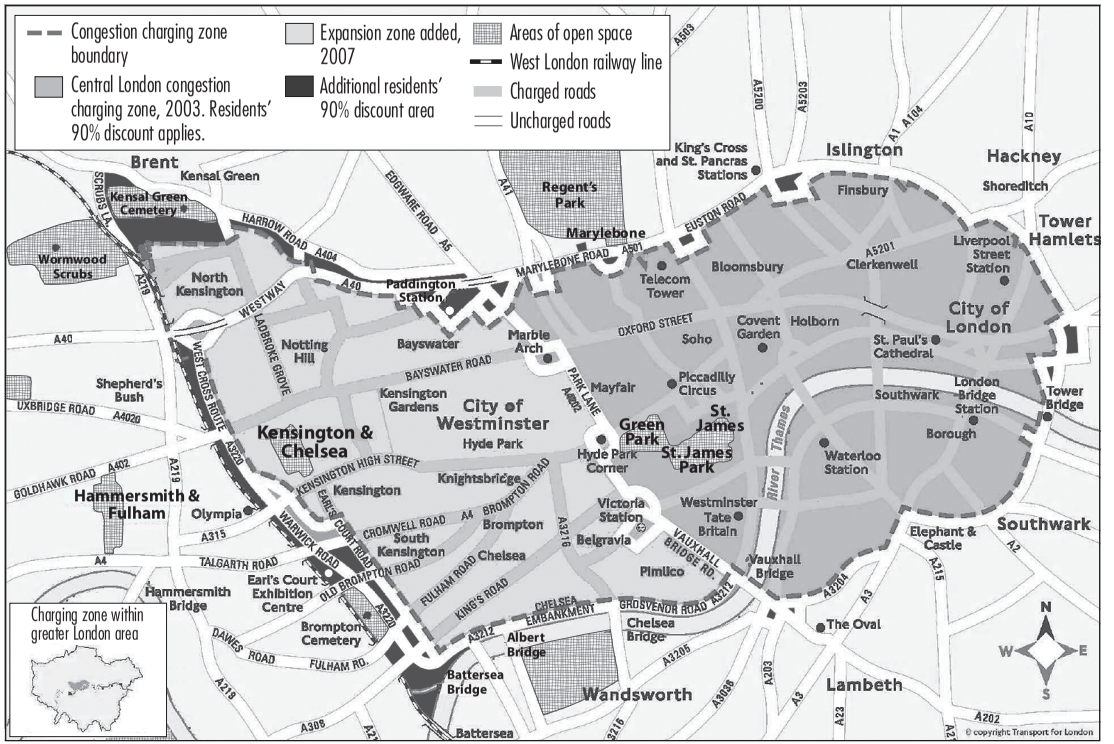
London London's cordon, or zonal, congestion pricing program was launched in February 2003. The program requires that vehicles crossing into, leaving, or traveling within the charging zone pay a standard daily fee. (Initially set at £5, the fee was raised to £8 in 2005.)[2] Numerous exemptions and discounts are allowed, including substantial discounts for residents of the charging zone. Initially designed to reduce weekday congestion in a central city zone bounded by a ring road, the zone was extended westward in February 2007, creating a single enlarged zone (see figure 10.2).

Traffic adjusted rapidly to the pricing system. After the first year of operation, traffic circulating within the charging zone was reduced by 15 percent during charging hours. The number of vehicles entering the zone was reduced by 18 percent. Although traffic increased on the inner ring road (a possible diversionary route around the charging zone), the increase was less than expected, and no operational problems were observed. No significant increase in traffic was evident outside the charging hours or in the area surrounding the charging zone. Traffic approaching the charging zone was reduced, and no significant change in traffic

1. The June 2010 exchange rate was S$1.40 = US$1.

2. The June 2010 exchange rate was £1 = US$1.50.

Figure 10.2
Central London Congestion Charging Zone



Source: © TfL (2007). Reprinted with permission.

levels was observed on nearby local roads. According to Transport for London (TfL), the local governmental body responsible for the program, "The balance of evidence was pointing to an overall 'background' decline in traffic in central and inner London" (TfL 2007, 18).

Traffic levels observed in 2003 were basically maintained in 2004 and 2005, with some evidence of modest overall reductions in traffic coinciding with the increase in the congestion charge in July 2005. By 2006 key traffic improvements achieved were being maintained, with the balance of evidence suggesting further small declines in total traffic in and around the central charging zone. TfL reported, "Overall patterns of traffic established following the introduction of the scheme in 2003 have again remained largely unchanged." Traffic entering the central charging zone during charging hours in 2006 was 21 percent less than in 2002, before charging began. According to TfL, "As in previous years, available traffic indicators outside the central London charging zone have continued to indicate small background declines to overall traffic levels, with no evidence of significant adverse effects" (TfL 2007, 19).

Stockholm Following more than three decades of study and debate, Stockholm launched a six-month pilot test of congestion pricing in 2006. The goals of the cordon pricing program were to reduce congestion, improve the environment, and generate revenues for transportation improvements. After completion of the trial, the program was evaluated, and in August 2007 it was made permanent.

The priced area includes a central city zone of roughly 20 square miles (half of which is either river or sparsely developed). This area constitutes only a small part of the larger urbanized county area (population 756,000 in the priced zone versus 1.8 million in the county). Vehicles are charged when entering or exiting the priced zone at 18 crossings. Although charges vary by time of day, there is a maximum daily charge. A number of exemptions also exist, including an exemption for vehicles traveling through the priced zone without stopping (roughly one-quarter of the vehicles passing a charging point are not charged). No charges are levied on weekends, on public holidays (including the day before a holiday), and during the month of July.

In the first phase, overhead gantries at each charging point identified the transponder in a passing vehicle and automatically deducted the charge from a preestablished account. Payments could not be made at gantry sites. Cameras captured photos of all vehicles' license plates. Vehicles without transponders or accounts had until noon the next day to make payment, using a Web site, retail outlets, banks, or kiosks. Fines were established for violations. Since the initiation of the permanent system in 2007, automatic number plate recognition technology similar to that used in London has been employed. At the end of each month, the Swedish Road Administration sends out a "tax decision" to each vehicle owner, providing notification of road charges accumulated. The tax is due by the end of the following month.

An evaluation of the pilot test showed that the charging program met or exceeded the goal of a 10–15 percent reduction in traffic. Congestion was reduced dramatically, and traffic speeds increased. The worst traffic queues in the city center were reduced by 30 percent or more. There was no significant increase in traffic bypassing the city center. Travel time reliability improved, and traffic volume on the most heavily traveled routes dropped by 20–25 percent. Public transit use increased by 6–9 percent, though not all of that change could be attributed to the charging program. Data suggest that less than half of the auto users who gave up a trip during the charging period shifted to transit. Few commuters changed their time of departure. No significant increases were observed in cycling, carpooling, or telecommuting.

OTHER CONGESTION PRICING PROGRAMS

Several other pricing programs have been initiated worldwide.

- *Norwegian toll rings*. The cities of Oslo, Bergen, and Trondheim have many years of experience with toll cordons around their central cities. Vehicles crossing the cordon are charged a toll, depending on the time of day. These programs have produced some reductions in road use during the priced periods and generated new revenues. The revenues have been used to fund road improvements.
- *Intercity routes in France*. Since the early 1990s, several autoroutes in France have adopted variable tolls to encourage shifts from peak to off-peak travel periods or from more to less congested routes.
- *Seoul Nam San tunnel congestion pricing*. The peak-period surcharge here resulted in a change in tunnel traffic composition and a reduction in daily traffic through the tunnels.
- *GPS-based truck tolls in Germany*. Germany introduced GPS/GSM-based tolls for all trucks traveling on major highways. The tolls vary by distance traveled and by the number of axles and emission rating of each vehicle. The program generates annual revenues in excess of US$4 billion, half of which are used for highways and the other half for rail and inland waterways.
- *Variable on-street parking pricing*. For many years, some international cities (including cities in Ireland and Israel) have operated location-, time-, and duration-specific differential parking rates for on-street curb spaces within their central zones. Such programs have rationalized the use of curbside parking supply, reduced travel, and generated revenues.

CONCLUSIONS BASED ON INTERNATIONAL CONGESTION PRICING EXPERIENCE

Pricing projects have been implemented in Canada, the United Kingdom, France, Norway, Sweden, Germany, Switzerland, South Korea, Singapore, and Australia over the past three decades.

Mobility Without exception, areawide pricing strategies implemented abroad have met their principal objective of reducing congestion over long periods. Areawide pricing in Singapore, London, and Stockholm have resulted in 10–30 percent or greater reductions in traffic in their priced zones, and these reductions have been sustained over time (for more than 30 years in Singapore and 5 years in London). Speeds have increased 10–30 percent within the zones as well as outside them, along approach roads. Buses in Singapore and London have particularly benefited from the increases in speed. In all three cities, up to 50 percent of the people forgoing car travel to the priced zones shifted to public transportation. In London and Stockholm, the greatest shift away from car travel was to public alternatives. In Singapore, the biggest shift was to four-plus car pools and to the shoulder time just before the start of pricing.

Revenues/Costs The significant revenues generated by congestion pricing have been seen as an important source of benefits in all three cities. Project revenues in London and Stockholm (as well as in cordon pricing projects in Norwegian cities) have been used to cover operating and enforcement costs first, and remaining revenues have funded improvements to bus and rail services. In London and Stockholm, the desire and ability to use pricing revenues for public transportation was a major objective and selling point. In Singapore, although revenues are not directly earmarked for public transportation, the availability of these funds probably has allowed the government to pursue ambitious public transportation programs more easily.

In Singapore, revenues are nearly 14 times the operating costs. If capital costs are included, revenues are still 2.5 times the total costs. For the London charging program, revenues have been a little over twice the operating costs. Inclusion of capital costs brings this ratio down only marginally.

Areawide pricing projects in these cities are also generating revenues far in excess of costs. In Singapore's ALS, for example, revenues were more than 10 times the operating costs.

Economy and Business Areawide congestion pricing programs have likely produced societal and economic benefits in excess of costs. Singapore's Phase I program implemented in 1975 is estimated to have achieved a rate of return on investment of at least 15 percent, even without including realized savings other than the value of time savings. The London scheme is estimated to have generated a benefit-cost ratio of 1.4.

Regarding business impacts, surveys in Singapore suggest that the pricing has not changed business conditions or location patterns. Overall, the business community has responded positively to the program. Analysis indicates that pricing in London has had neutral regional economic impacts, although annual surveys suggest that businesses in the priced zone have outperformed those outside the zone. Most businesses continue to support the charging scheme, provided that investments in public transportation are continued. In Stockholm surveys, albeit

over a very short time span, have found no identifiable impacts on retail business or household purchasing power.

A long-term study of overseas congestion pricing conducted by CURACAO (2007) found a generally low level of measured impact on regional economies. Although this result may be partly attributable to the unique economic vitality and strength of the cities in which pricing occurs, there is no evidence of economic damage.

Environment A better environment was one of the primary objectives of the Stockholm pricing program, though not a major objective of the London and Singapore programs. All three cities, however, have attempted to monitor and measure the air quality implications of changing vehicle operating speeds, number and timing of trips, and mode of transportation on which trips are taken. Evaluators in Singapore concluded that tailpipe emissions most likely declined in the priced zone because there was such a large reduction in automobile travel. Measurements of smoke and haze showed declines, but they could not be unambiguously attributed to pricing. In London, analysis has shown changes in air quality within and along the inner ring road. Nitrogen oxide levels fell by 13.4 percent between 2002 and 2003, carbon dioxide by 15 percent, and particulates (PM10) by 7 percent. More recent analysis has confirmed this trend. Although some of these reductions can be attributed to less traffic flowing more smoothly, most are due to improved vehicle technology.

Thus, generally it appears that areawide pricing has played a role in reducing pollution. The expansion of public transportation, made possible by congestion pricing revenues, also has the potential to reduce pollutants and sustain reductions over time.

Equity Equity impacts have received general analytic attention, but little project-level evaluation. The focus has been on varying concepts of equity, modeling of impacts, and pricing designs to address income equity issues.

At the project (or proposed project) level, Singapore examined equity impacts; Edinburgh has grappled with equity and general fairness considerations; and several toll rings in Norway have been designed with equity in mind. But no detailed equity evaluations have been conducted after project implementation. Among the three cities reviewed here, the perception that congestion pricing is unfair to low-income drivers has not been a major concern since implementation. The findings from Singapore are the most in-depth, but Edinburgh's experience with its proposed pricing plan is also instructive.

In Singapore, the results of a modeling analysis based on before-and-after user survey data suggest that "gainers" outnumbered "losers" 52 percent to 48 percent. Attitudinal surveys carried out after program implementation found that pedestrians, taxi riders, and residents outside the priced zone saw the impact of pricing as neutral or negative, while cyclists, bus passengers, and residents within the zone saw it as favorable. Car drivers and passengers judged the impact

to be mildly unfavorable. Travel evaluations and stakeholder surveys found that increases in transit were fairly uniform for low-, middle-, and high-income peak-period travelers. The evaluators concluded that overall there were only small differences among income groups in modal shifts due to pricing. There was also no evidence that trip times increased or decreased more for any particular income group.

In Edinburgh, issues of revenue distribution and transit improvements were vital to geographic equity considerations in presenting the congestion pricing proposal. Noncity residents viewed revenue distribution plans as unfair, since they would pay the charge but not get any direct benefit. A key institutional issue appears to have been that neighboring authorities had no legal grounds to support public transport improvements that might have appealed to noncity residents. City residents also would have benefited disproportionately from the public transport improvements. In short, the defeat of the Edinburgh proposal shows how geographic equity and improvement issues can make or break pricing plans. A CURACAO publication reviewing equity issues across programs urges attention to the design of pricing programs, including location, time of day, and level of charge; the use of exemptions and rebates; the provision of travel alternatives; and the use of surplus revenues to moderate perceived equity issues.

Acceptability Based on project experience and public opinion studies on pricing, certain key factors emerge as potential determinants of public acceptance.

- *The problem addressed resonates.* Whatever the mix of problems addressed by pricing proposals—whether congestion, pollution, or some combination—acceptability is enhanced where the problem is perceived as clear and severe by affected parties. Congestion may or may not be the most central problem addressed by pricing; pollution may be more resonant. When pricing plans home in on the most cogent problem or problems, implementation prospects are enhanced.
- *Pricing is convincingly effective.* Acceptability studies suggest that the public or decision makers may be skeptical about the effectiveness of pricing in reducing congestion or pollution. The implication is that the prospects for success are better when proposals can demonstrate effectiveness, perhaps by reference to like projects, through well-evaluated test programs, or both.
- *Program design meets program concerns.* Acceptability of pricing is enhanced where program parameters are in line with public and decision maker concerns. Top issues will vary by area, but planners increase the odds of acceptance by structuring the program to address those issues. The most common concerns include questions about free riders, enforcement, the complexity of the technology, and the prospect of specific groups facing hardship or adverse boundary effects.
- *Revenue distribution follows preferences.* Using revenues for the most favored purposes is important to acceptability. Research shows that revenues

directed toward transit and/or road improvements may garner support in some locations, but may compete with other preferences, such as possible tax reductions, elsewhere.

- *Fairness is broadly addressed.* Equity across income groups is often the source of much discussion among analysts of road pricing. However, research shows that acceptability does not vary greatly across income groups and that equity defined more broadly may deserve more attention. Specifically, the following fairness perspectives may be key: fairness of outcomes (the assurance that some who should be paying will not evade the pricing scheme); procedural fairness (everyone has an opportunity to participate in developing pricing plans); fairness to special groups (e.g., people with handicaps or emergency workers); use and spatial fairness (occasional payers reap the same benefits from new roads and transit as frequent users); and fairness to different trip types (ways to moderate different treatment of trips traveling wholly within and those taking place to/from the pricing area).
- *Government planners are open, responsive, and resourceful solution partners.* Numerous findings suggest that how government pricing planners are perceived may be as important to acceptance as the nature of their pricing proposals. If government has a favorable image in coping with bottlenecks, improving transit, and improving traffic management, acceptability of pricing proposals is enhanced. Also important is sensitivity to government's image as a taxing entity with already sufficient resources to deal with congestion. Transparency in pricing planning and decision making will enhance acceptability, including the degree to which nonpricing options and pricing experience elsewhere are examined. The view of government as a resourceful partner in seeking solutions to congestion is important to acceptance, suggesting that state and national government agreements and matching funds may be a necessary component.
- *Pricing schemes operate over time.* Acceptance tends to grow the longer pricing programs are in existence. The exact reasons for growing acceptance are not well explored. It may have to do with demonstrating no harm to business, the absence of feared queues at toll facilities, and the visible link between revenues and transportation improvements.

In terms of implementing pricing programs, a few key points emerge from overseas experience.

- *Areawide pricing often requires new policy and institutional arrangements.* Major national legislative initiatives were enacted before areawide pricing could be implemented in London and Stockholm. Experience shows that formal agreements may be needed to give pricing entities the power to impose and collect charges; to use selected technology to administer and enforce charges; to cite violators and collect fines; to modify the pricing scheme; and to use the revenues from charges. Experience also shows that

policy and institutional arrangements and agreements have a profound impact on public and political acceptability of areawide pricing proposals and operational success. Acceptability research shows that stakeholder involvement and funding across government levels are important as well.

- *Successful projects depend on effective outreach and sensitivity to public acceptability.* All of the overseas projects have paid considerable attention to measuring public attitudes and reaching out to the public, stakeholders, and elected officials to further understanding of pricing and assess reactions. Outreach efforts as part of initial feasibility studies are often met with neutral or skeptical reactions and even outright resistance, which may be followed by acceptance as projects get under way. The support of a key stakeholder or senior politician who is able to influence public opinion seems crucial to improving implementation prospects. While businesses have not been obstacles to implementation and are generally accepting of congestion pricing, continued support, at least in London, appears to hinge on continued investment in public transportation.
- *Effective, reliable, and acceptable pricing and enforcement technologies are key to implementation.* Technology is important to the success of most pricing programs, and it has generally been up to the task. Various technologies for pricing and enforcement, both low-end and high-end, have proved reliable and effective. For example, Singapore's manual ALS program worked well in the early stages, and its electronic successor, ERP, is working well now. London's automatic plate number recognition system has been effective, though plans are under way to move to an electronic system that will reduce administrative costs and allow for variable pricing schedules.

Areawide Pricing and Land Use

There is agreement that areawide congestion pricing is likely to have a significant impact on economic activities within the affected zones, as well as in surrounding areas. Pricing changes affect costs of travel for cars, competing modes of travel, and freight traffic. All of these changes may influence the costs of doing business and, in time, land uses and development patterns (land values, rents, availability of labor, and locational decisions).

A COMPLEX RELATIONSHIP

The relationship between transportation and land use is complex. The economic and relocation impacts of transportation are difficult to identify and measure. These impacts often take a long time to materialize, and it is difficult to separate the effects of congestion pricing from other influences. Tracing the effects of pricing on land use is further complicated by the fact that businesses and residents have ample opportunity to adapt to pricing, and that adaptation might take many different paths, with varying implications for land use changes. This situation is

made even more difficult by the very limited experience with pricing programs. Much remains to be researched beyond the mostly inconclusive modeling efforts undertaken to date.

In attempting to understand the land use implications of congestion pricing, two opposite arguments can be put forward (Deakin 1994). On the one hand, one can argue that persistent underpricing of highways in the United States has encouraged urban sprawl and that congestion pricing, by increasing travel costs, could encourage denser development. On the other hand, it has been argued that congestion pricing could facilitate further decentralization because it would reduce the attractiveness of priced areas. In addition, existing zoning statutes, which are notoriously difficult to modify, would continue to discourage denser development patterns.

According to Deakin (1994, 53), "Neither theory nor research on the relationship between the costs of travel and urban development provides compelling evidence to support whether congestion pricing would have a centralizing or decentralizing effect." The evidence from Singapore, London, and Stockholm, as described in the next section, also provides little definitive guidance in this regard. By and large, most ongoing programs (and even some unsuccessful ones) that have carefully assessed many other impacts have largely avoided addressing land use effects.

The possible impact of pricing on urban form is complicated further by the uncertainty in the intended use of program revenues and by the unknown steps businesses might take to minimize impacts. For instance, if businesses and residents in priced areas receive compensation to mitigate perceived adverse impacts, land use effects might well be minimized. If revenues are used to expand and ease access to priced areas, the implications for land use could be significant (Deakin 1994).

Regarding employment and residences, a question often posed is whether pricing will induce workers to move closer to their workplaces or whether workplaces will move away. There are two major difficulties in answering this question: first, as mentioned earlier, many other factors influence locational decisions; and second, such decisions take place over a long time frame, and except for Singapore, our experience with pricing programs is very recent and very limited.

In the absence of definitive evidence from the very few ongoing programs and from inconclusive modeling analyses, it is difficult to design pricing programs specifically to encourage desired land use outcomes. Uncertainty about land use impacts has also continued to spawn resistance to congestion pricing programs by affected interests—particularly those opposed to the concept for other reasons. In every areawide pricing project implemented to date or rejected after careful consideration, retail and commercial interests within the priced zone had strong negative reactions to the proposal, putting forth the argument that the central business district would become much less attractive due to the increased cost of travel to it.

EVIDENCE RELATING TO ECONOMIC AND BUSINESS IMPACTS

The lack of empirical evidence regarding congestion pricing's impacts on land use makes estimating such impacts difficult. After Singapore's ALS was introduced in 1975, businesses were asked for their assessment of the pricing scheme. Their response was largely positive. However, as a CURACAO report (2007, 17) points out,

> 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 centre (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, masking any impact of road pricing.

While we have little direct evidence pertaining to the long-term land use impacts of congestion pricing, the programs in Singapore, London, and Stockholm are generating some, albeit limited, information about economic and business impacts that might also have long-term land use implications.

Singapore Although an objective assessment of business impacts based on long-term economic data has not been not carried out in Singapore, stakeholder surveys were conducted to derive plausible impacts of the ALS on certain dimensions of business productivity. In the absence of time series data, an analysis of the surveys suggested that the pricing scheme by itself did not appear to be a factor in rents and did not seem to have had a negative impact on office development in the priced zone. Other factors appeared to be much more important to investment decisions.

Regarding retail sales, in 1976 it appeared that the ALS had a minor impact on sales in the priced zone compared to other economic and development factors. Hotel representatives did not see any appreciable negative impact of the ALS. Overall, the ALS by itself was not perceived as a negative factor. In contrast, when the ALS was modified in 1989 to cover afternoon peak travel, some retail shops reported sharp declines in afternoon trade, and some resorted to offering ALS fee reimbursements.

Post-ALS implementation surveys also found that the ALS apparently did not adversely affect labor availability, although this may have been more due to improved public transportation. Over several years, when employment in the entire country of Singapore increased by 32 percent, employment in the central area increased by 34 percent.

Thus, it appears that the ALS did not initiate changes in business conditions or location patterns. Overall, the business community responded positively to the

pricing program, probably believing that the combined package of actions by the government was necessary and beneficial in the long run.

London A 1996 model-based analysis of the impacts of congestion charging in London predicted that a £4 charge to enter central London would result in an increase of 1 percent in central London employment, while inner and outer London employment would fall by 0.5 percent. The model also suggested that the number of households would fall by 0.2 percent in central London and 0.1% in the outer ring, and that the number would rise slightly in the inner ring. The number of higher-income households in central London was also predicted to increase.

London authorities have monitored the impacts of congestion charging since its start in 2003, using business surveys, employment data, property values, and information on business turnover and profitability. TfL (2005, 2006, 2007) reports that the pricing seems to have had broadly neutral economic impacts. It found that charging did not have a significant impact on various indicators of economic performance, including measures of business population and turnover and of shops within the inner core of the charging zone whose rental values had increased. TfL's business surveys conducted in 2004 showed a continuing recognition of the transport benefits associated with charging. Annual surveys suggest that businesses in the charging zone have outperformed those outside the zone, and a majority of businesses continue to support the charging scheme, provided investments in public transportation continue.

The experience in London shows that business support for congestion pricing is generally positive but relatively mixed. On the whole, businesses in London were more supportive of the scheme than opposed to it. When analyzed by sector, however, the leisure, financial, and retail sectors were the most supportive, while the distribution and restaurant sectors were the least supportive. An increased level of support from the retail sector in 2005, compared to the previous year, was the most positive trend in all the sectors (TfL 2005).

Stockholm The Stockholm pricing program is too recent to have had a significant influence on land use, real estate prices, or the regional economy. However, early surveys of business leaders suggest that pricing is likely to have little effect on these dimensions. Similarly, no identifiable impacts on retail business or household purchasing power have been identified. However, a model-based analysis of a permanent congestion tax in Stockholm found that there would be an effect on the appeal of certain areas, measured by falling housing prices. This effect would be extremely modest, though, compared to the changes that normally occur in the housing market. The model also assumed that the effects on traffic and accessibility would be worse than the effects that have actually been measured during the operation of the program. Most likely, factors other than a congestion tax will determine housing price trends in the area.

Model calculations of the effects on residential property and places of work showed that over the long term, prices in both the inner city and the surrounding area would fall by 1 percent as a result of the change in accessibility resulting from a permanent congestion tax. This would not be a great change over the 20- to 30-year prediction period, however, so congestion pricing is not expected to have any great effects on the expansion of residential or commercial areas.

United States Two recent transportation–land use modeling simulations in the United States found that retail production in priced areas was not expected to be affected significantly by pricing (Gupta, Kalmanje, and Kockelman 2006; Safirova et al. 2006). These simulations seem to support the arguments of the proponents of pricing programs.

In summary, the generally low level of measured economic and business impacts appears to refute the perception that congestion pricing will lead to substantial out-migration of residents and businesses. Available evidence suggests small, neutral, or no significant negative impacts on business activity.

- In London, pricing has not had a significant impact on several different indicators of economic performance. TfL's business surveys conducted in 2004 showed a continued recognition of the transportation benefits associated with congestion charging. The most recent assessment, in 2007, suggests that the scheme's impact on the London economy has been broadly neutral.
- The mayor of London's original business case for the charging scheme suggested that congestion cost the London economy £2–4 million per week in lost time. TfL has predicted that the range of public transport services available is saving Londoners about £3.5 million per week.
- Based on data from the summer of 1992, the Trondheim, Norway, Chamber of Commerce concluded that there was no significant effect of the toll ring on trade.
- In Stockholm, sales and consumer surveys in the early years after the start of the program showed that the congestion tax had no negative effects on retail trade and little effect on companies' total transportation costs and households' disposable income and purchasing power.

A Look to the Future

Much has been learned about the potential of areawide congestion pricing over the past several years, but much more remains to be learned. Long-run impacts on land use, auto ownership, business, and productivity need to be monitored over time. Continued progress in implementing acceptable and effective pricing programs has required careful planning, coalition building, public education

and participation, and sufficient time and resources for the development of well-designed and locally acceptable plans. Given the overseas track record to date, more programs can be expected to be implemented, and these will provide much-needed long-term lessons.

Areawide pricing holds the promise of reducing congestion, enhancing mobility and economic productivity, reducing environmental and energy costs, and providing new sources of funding for transportation. Despite this potential, the concept of congestion pricing remains controversial in many places. The overseas experience can provide a valuable guide to planners in exploring the feasibility of pricing applications and identifying projects for implementation.

A particularly important consideration in some U.S. cities considering areawide pricing is the use of revenues generated by pricing to address and mitigate specific equity issues. At the same time, pricing programs abroad have demonstrated the wisdom of employing a broad definition of equity and a general attention to fairness versus focusing only on income equity. Indeed, the extensive findings summarized here point to a link between fairness and acceptability of pricing proposals.

Finally, the overseas experience suggests the need to pay more attention to the potential environmental and energy benefits of pricing. Overseas analysts have reported limited but important preliminary findings about air quality impacts, and more work in this regard can be expected. Although the air quality and energy conservation benefits of the small-scale U.S. pricing projects implemented to date may have modest effects on overall regional environmental quality, areawide projects beginning to receive attention in the United States may have greater potential benefits. U.S. planners would do well to pay continued attention to environmental results and evaluation methods from overseas.

REFERENCES

AECOM Consult. 2006. *International urban road pricing*. Final Report (June). Prepared for the Office of Transportation Policy Studies, Federal Highway Administration. Washington, DC. http://www.ncppp.org/resources/papers/fhwainternationalcase606.pdf.

Armstrong-Wright, A. T. 1986. Road pricing and user restraint: Opportunities and constraints in developing countries. *Transportation Research Part A: General* 20(2):123–127.

CURACAO. 2007. *Work package II: State of the art report*. Draft. Coordination of Urban Road User Charging and Organisational Issues, University of Leeds, for the EC Curacao Project, U.K. http://www.curacaoproject.eu/.

Deakin, E. 1994. Urban transportation congestion pricing: Effects on urban form. In *Curbing gridlock: Peak-period fees to relieve traffic congestion*. Transportation Research Board Special Report No. 242. Washington, DC: National Academy Press.

Gupta, S., S. Kalmanje, and K. M. Kockelman. 2006. Road pricing simulations: Traffic, land use and welfare impacts for Austin, Texas. *Transportation Planning and*

Technology 29(1):1–23. http://www.informaworld.com/smpp/content~content=a743854632&db=a.

KTA (K. T. Analytics and Cambridge Systematics). 2008a. *Lessons learned from international experience in congestion pricing* (August). FHWA-HOP-08-047. Washington, DC: Federal Highway Administration. http://ops.fhwa.dot.gov/publications/fhwahop08047/intl_cplessons.pdf.

———. 2008b. *Value pricing pilot program: Lessons learned* (August). FHWA-HOP-08-023. Washington, DC: Federal Highway Administration. http://ops.fhwa.dot.gov/publications/fhwahop08023/vppp_lessonslearned.pdf.

Land Transport Authority of Singapore. 2008. REP rates. *One Motoring*. http://www.onemotoring.com.sg/publish/onemotoring/en/on_the_roads_ERP_Rates.html.

Menon, G. 2005. International symposium on road pricing. *Proceedings*. Washington, DC: Transportation Research Board, National Research Council.

New York State. 2008. Report to the Traffic Congestion Mitigation Commission and recommended implementation plan. New York State Traffic Congestion Mitigation Commission (January 31).

Safirova, E., S. Houde, D. A. Lipman, W. Harrington, and A. Baglino. 2006. Congestion pricing: Long-term economic and land-use effects. Working Paper No. RFF-DP-06-37. Washington, DC: Resources for the Future.

SANDAG (San Diego Association of Governments). 2001. FastTrak Phase II, Overall Report.

Schaller, B. 2010. New York City's congestion pricing experience and implications for road pricing acceptance in the United States. *Transport Policy* 17:266–273.

TTI (Texas Transportation Institute). 2007. Urban mobility report, table 4. College Station: Texas A&M University.

TPB (National Capital Transportation Planning Board). 2007. Evaluating a network of variably priced lanes for the Washington metropolitan region. Washington, DC: Metropolitan Washington Council of Governments.

TfL (Transport for London). 2003. Congestion charging 6 months on. London.

———. 2004, 2005, 2006, 2007. Central London congestion charging: Impacts monitoring. *Annual Reports*, London. http://www.london.gov.uk/mayor/economic_unit.

TRB (Transportation Research Board). 2005. International symposium on road pricing, conference. *Proceedings*. Washington, DC.