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TECHNICAL REPORT

Equity and Congestion Pricing

A Review of the Evidence

Liisa Ecola • Thomas Light

Sponsored by the Environmental Defense Fund

Transportation, Space, and Technology

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

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Preface

Transportation policymakers are increasingly considering congestion pricing a promising option for addressing urban traffic-congestion problems. While some congestion pricing projects have been undertaken in the United States, many proposals have been rejected based on worries that congestion pricing is inequitable. The goal of this report is to look at the evidence that might support or negate this claim. As congestion pricing has been both studied and implemented more widely, a body of evidence based on both real-world implementations and models of proposed and hypothetical congestion pricing systems has been growing. While a number of papers have been published in this area, it has been difficult to reach general conclusions about whether congestion pricing is equitable. This report provides an overview of the literature from both economists and transportation planners to highlight what is known about the equity implications of congestion pricing.

The study was sponsored by the Environmental Defense Fund (EDF), although the views expressed herein are those of the RAND authors and do not necessarily reflect those of EDF. As with all RAND research, the RAND Corporation maintains full editorial control over the content and conclusions of its reports. The report should be of interest to transportation planners, elected officials evaluating congestion pricing proposals, economists, and others with an interest in congestion pricing.

RAND recently released a report on short-term strategies to deal with congestion in the Los Angeles region that addressed the role of congestion pricing. See Sorensen et al. (2008).

The RAND Transportation, Space, and Technology Program

This research was conducted under the auspices of the Transportation, Space, and Technology (TST) Program within RAND Infrastructure, Safety, and Environment (ISE). The mission of RAND Infrastructure, Safety, and Environment is to improve the development, operation, use, and protection of society's essential physical assets and natural resources and to enhance the related social assets of safety and security of individuals in transit and in their workplaces and communities. The TST research portfolio encompasses policy areas including transportation systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy.

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Congestion pricing has become an increasingly viable option for managing congestion and raising revenue for transportation investments. Once relegated to academic discussions, congestion pricing can now be more easily implemented thanks to technologies that make it possible to charge motorists as they drive. Because of these technological advances, congestion pricing has been implemented in various forms in a number of countries, including the United States.

However, congestion pricing tends to raise equity concerns among both the public and elected officials. Since congestion pricing imposes a cost on something that was previously free—access to roadways during peak driving times—critics often suggest that it will harm those with lower incomes who will be forced to pay additional costs or be priced off the roads.

On the other hand, supporters argue that congestion pricing can be more equitable than the current U.S. system for managing the use of roads and funding transportation improvements. First, congestion pricing means that those who contribute most to congestion will be required to pay more. Second, existing transportation fees and taxes, such as the motor-fuel tax, are often regressive, meaning that low-income drivers pay a higher proportion of their income toward them than wealthier drivers do. If broadly adopted, congestion pricing revenues could be used to offset or reduce other regressive fees and taxes. Finally, some argue that congestion pricing can reduce air pollution, which is, in many cases, a serious problem in low-income neighborhoods located near major freeways and arterials, and promote better management of the roadway network, thus avoiding costly capacity investments.

This report examines the equity issues associated with congestion pricing. We used published work, supplemented in a few cases with communication with practitioners, as the basis for the analysis. The evidence we reviewed came from two types of sources: evaluations of existing congestion pricing implementations and models of proposed or hypothetical congestion pricing systems. We found work on equity with regard to congestion pricing in two strands of literature: economic and planning. The former is most often concerned with the distribution of costs and benefits that accrue to society, while the latter is generally concerned with social-justice aspects of congestion pricing and the potential negative consequences for low-income and other disadvantaged individuals.

While equity is broadly concerned with the costs and benefits that accrue to different members of society, specific notions of equity can vary a great deal. In particular, four notions of equity commonly cited in the congestion pricing literature include (1) horizontal equity (members of the same group are treated the same); (2) vertical equity (members of different

groups are treated differently); (3) the cost principle (those who contribute to a social cost pay for doing so); and (4) the benefit principle (those who receive social benefits pay for them).

When congestion pricing is evaluated, it may fare well under some notions of equity but poorly under others. This issue is not easily resolved. For example, since those who contribute to congestion pay to drive during congested hours, congestion pricing fares well on the cost principle. On the other hand, if people in the same income group pay widely different amounts in congestion tolls because of where they live or work, congestion pricing does not fare well in terms of the horizontal-equity principle. While these aspects of equity can be stated precisely, calling one policy or set of outcomes more equitable than another requires that one impose some preferences on the way in which benefits and costs are allocated within society.

Another problem is that, since assessing the equity implications of congestion pricing requires comparisons of people from different groups, the ways in which the groups are drawn makes a difference to the outcome. The economics literature tends to group people based on their income or where they live and work, whereas the planning literature tends to look at the broader category of those who may be in some way disadvantaged with respect to transportation (e.g., because of disability, age, gender, or language ability). Particularly important with respect to congestion pricing is where people live—because of the way in which congestion pricing is implemented, some neighborhoods may bear a far greater burden than others. So, an equity assessment that considers only income may reach a different conclusion if the basis for the assessment is the neighborhood.

For all these reasons, we argue that there is no single answer to the question, "Is congestion pricing equitable?" The answer depends on how we measure equity and define groups, the specifics of the location, and to what we compare congestion pricing. Since it is not generally possible to consider all the numerous facets of equity, it is important for a region considering congestion pricing to select the most relevant criteria for assessing equity given local conditions and concerns.

That said, in reviewing the literature, we did attempt to determine whether there were any broad conclusions that might help address the questions that are often posed with regard to equity and congestion pricing. The main findings are described next.

First, depending on how congestion pricing is implemented, it can be either regressive or progressive. This depends in large part on how toll revenues are used. For instance, if regions spend revenues in ways that benefit low-income individuals, congestion pricing is more likely to be progressive. However, if regions use revenues in a way that benefits all individuals equally, congestion pricing may be, overall, regressive. This is the strongest finding in the economic literature.

Second, even when low-income and other transportation-disadvantaged groups benefit as a whole from congestion pricing, it is very likely that some individuals will still be worse off. These include people with no choice but to drive on congested routes with pricing in effect and those who may have to forgo important trips because they are too expensive. However, many of these same people are also disadvantaged by the current transportation system, and assessments of equity should take this into consideration.

Third, for all forms of congestion pricing (but more for some than for others), the distribution of residents and job opportunities (not to mention shopping, schools, places of worship, and other important destinations) has a large impact on the equity implications. One study, for example, found that cordon pricing, a form of congestion pricing in which drivers pay to enter

a designated area, can be progressive, regressive, or neutral depending on where low-income people live.

Fourth, high-occupancy toll (HOT) lanes, the most common form of congestion pricing in the United States, tend to raise fewer equity concerns among motorists, since they provide drivers with an additional choice of using a set of priced lanes while allowing them to continue using parallel, free lanes if they prefer. While high-income drivers use HOT lanes more often than other drivers, there is little evidence that low-income drivers are made worse off. However, the equity implications of HOT lanes are affected by the location of residents, the costs of participation, and the way in which revenues are utilized. Some analysts have raised concerns that, if HOT lane revenues are used to expand the road network, they will harm the environment and equity by inducing more traffic growth and sprawl.

Fifth, while congestion pricing has been shown to reduce emissions in general, there is scant evidence showing that congestion pricing can specifically reduce negative environmental consequences for neighborhoods disproportionately affected by emissions.

Finally, we found very little or no literature on some topics that we consider important. In addition to the dearth of research on the environmental-justice impacts, there was very little work on the long-term land-use impacts of congestion pricing, the equity implications of building new roads with congestion pricing revenue, and how adding congestion pricing to existing transportation-finance mechanisms (as opposed to replacing them) would change the equity implications overall. Now that congestion pricing is in more widespread use, we recommend that these topics receive further attention by researchers.

Given the risk of negative impacts to low-income and other groups under congestion pricing, we looked at suggested ways to diminish these impacts. Two mechanisms are in common use: (1) revenue redistribution and (2) discounts and exemptions. Revenues from congestion pricing can be redistributed through public works—for example, increasing transit service to create better options not to drive. For this to be effective, the project benefits must flow to those people most disadvantaged by congestion pricing. Researchers have also proposed a number of ways to redistribute revenues on an individual basis, through credit-based systems and tax credits. As none of these credit-based proposals has been implemented, it is difficult to judge their effectiveness.

The other main way to lessen the burden of congestion pricing is through discounts and exemptions. Congestion pricing proposals can selectively exclude or discount certain individuals (e.g., disabled persons), vehicles, or types of trips to make congestion pricing less expensive. However, the trade-off is a higher number of unpaid or discounted trips, which will reduce incentives that seek to discourage driving on congested roads.

The last point on promoting equitable outcomes is that a region seeking to implement congestion pricing should look at measuring and assessing equity early in the planning process. Since equity is so specific to individual regions, those responsible for developing a congestion pricing proposal should test it through modeling to determine who tends to pay charges and whether low-income or other transportation-disadvantaged groups are disproportionately affected. They should also conduct sufficient outreach that residents understand the proposal and have opportunities to offer suggestions. Finally, equity should be monitored after congestion pricing is implemented, and the system changed periodically if the initial tools to promote equitable outcomes are not meeting their goals. It would be useful to develop an "equity audit tool" to simplify this process.

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Abbreviations

CAFE	Corporate Average Fuel Economy
ETR	express toll route
FAIR lane	free and intertwined regular lane
FY	fiscal year
HOT	high-occupancy toll
HOV	high-occupancy vehicle
I	interstate
ISE	RAND Infrastructure, Safety, and Environment
NO_X	nitrogen oxide
PATH	Port Authority Trans-Hudson Corporation
SR	state route
TST	Transportation, Space, and Technology
VMT	vehicle-mile traveled

CHAPTER ONE

Introduction

Congestion pricing, which requires motorists to pay tolls based on the level of congestion, has been implemented in many parts of the world and has become a policy option widely considered in the United States. The federal government, through the U.S. Department of Transportation's Urban Partnership program, recently began providing hundreds of millions of dollars in funding to six metropolitan areas—Miami, Minneapolis–St. Paul, Seattle, San Francisco, Los Angeles, and Chicago—willing to implement congestion pricing. In addition, state and local congestion pricing studies are becoming increasingly common, with a number of major metropolitan areas in the United States currently considering some form of congestion pricing. Completed projects include high-occupancy toll (HOT) lanes in Southern California, Colorado, Minnesota, and Texas; HOT lanes are under construction in Northern California, Northern Virginia, and Maryland; and such cities as Atlanta, Charlotte, Los Angeles, New York, Portland (Oregon), Salt Lake City, San Francisco, and Seattle have studied applications of pricing to transportation.

Because of the growing focus on congestion pricing, concern is increasing over whether congestion-based charging policies can be designed in an equitable way. While equity can be evaluated in a number of ways, as discussed in Chapter Two, concerns about equity often surface with regard to the poor and other vulnerable groups. Some argue that, in the interest of reducing the burden on such groups, congestion charges should be limited, whether by reducing their geographic scope, narrowing the classes of vehicle subject to charges, or adjusting toll levels from standard, prescribed levels. Other means of addressing equity concerns include directing congestion pricing revenues or other funding toward specific investments, such as expanded or improved public-transportation options, or redistributing revenues to low-income drivers through credit-based proposals or mobility tax credits.

While the merits of congestion pricing have been debated extensively in both the popular and academic literature, there exists considerable disagreement over the likely impacts and proper design of congestion pricing policy. At the heart of this debate is disagreement over ways in which policymakers can or should trade off efficiency and equity objectives when designing transportation policy. This report seeks to inform the debate by addressing the question of whether congestion pricing can be an equitable alternative to other transportation policies currently employed to address urban congestion problems. We hope to accomplish two objectives: first, to bring findings from the economic and planning literature dealing with equity and congestion pricing to policymakers and interested citizens, and second, to help bridge the gap between economic analysis and a focus on social-justice concerns.

To set the stage for our evaluation, in this chapter, we explain the principles underlying congestion pricing and how these have been incorporated into road pricing proposals. After

this brief overview of congestion pricing, the report turns in Chapter Two to defining the terms that are often used in discussions about equity and fairness in the context of congestion pricing. Chapter Three looks at the evidence regarding impacts of congestion pricing on different classes of individuals. That chapter draws on analysis of actual impacts and insights from theoretical investigations. Chapter Four describes ways in which congestion pricing can be made more equitable. Concluding remarks are presented in Chapter Five.

Congestion Pricing in Theory and Practice

Since the seminal work of the economists A. C. Pigou (1920) and William Vickrey (1959, 1963), researchers have touted congestion pricing as an efficient means of managing congestion on urban roadways. Until recently, however, congestion pricing has been a largely academic concern. Policymakers have instead relied largely on roadway expansion as the primary means of addressing traffic-congestion problems. Today, because of environmental concerns, right-of-way costs, and stagnant funding sources, it is difficult and expensive to expand the most–heavily used highways and roads. This has led policymakers to place greater attention on other options, including congestion pricing, for addressing urban traffic congestion.

Congestion pricing is implemented by levying tolls that vary with the level of congestion to exploit the fact that pricing affects individuals' travel behavior. Individuals will tend to make fewer trips in more congested areas, use less congested routes, travel at less congested times of day, and be more likely to form carpools and use transit when roads are tolled based on their congestion levels.

Given this description, congestion pricing lends itself to two main purposes. First, congestion pricing can manage travel demand and therefore reduce congestion, because fewer drivers will use the roads during congested periods. This leads to better utilization of transportation capacity, which reduces emissions and fuel consumption, as well as the need to build new roadway capacity. Second, congestion pricing has the potential to generate significant revenues; if widely adopted, it can become an important source of funding for transportation infrastructure.

The economic theory of how to set efficient congestion tolls starts with the fact that individuals who drive on congested roads create costs for others. By entering a congested highway, one's vehicle takes up space, slows the speed of upstream traffic, emits pollution, increases the probability of vehicle collisions, and increases noise levels for other motorists and nearby residents and businesses. Because these costs are imposed on others without compensating them, motorists are unlikely to incorporate these impacts into their decisionmaking process. Congestion pricing seeks to remedy this by imposing a charge that reflects the monetized value of the *externalities* associated with driving.[1] This encourages motorists to behave in ways that more closely reflect the interests of others in society. Specifically, congestion pricing discourages drivers from taking vehicle trips during the most crowded times of day if those trips could be made at other times, on other modes, or on other routes or forgone entirely.

[1] An externality occurs whenever an individual's welfare or a natural resource is directly or indirectly affected—without recourse—by the action of another individual or group. In the case of traffic congestion, the externalities are entirely negative and include increased delay, exposure to pollution, elevated collision risks, noise, and emissions of greenhouse gases. The monetized value of these costs is sometimes called the *external cost* of congestion.

According to this theory, tolls on roadways should be implemented on all routes and reflect real-time variation in congestion levels. Economists sometimes describe this as *first-best congestion pricing*.

In practice, however, congestion pricing implementations cannot come close to this. Deviation between ideal and actual implementation conditions occurs because of political, technological, and public acceptance issues that make it difficult or costly to vary tolls over space and time at prescribed levels. As a result, a large body of literature has developed to analyze how the theory of congestion pricing should be modified (*second-best* approaches) to respect various tolling constraints (see Lindsey and Verhoef, 2001, for a review).

The primary forms of congestion pricing that have been implemented or have received notable consideration generally fall into one of the following five categories:

- *Time-, distance-, and/or place-based pricing:* This approach adjusts road-user charges based on the distance traveled, location, time of day, and vehicle type. Some proposals also adjust the toll based on vehicle fuel efficiency or pollution certification level. Among the advantages of this system is that it requires no infrastructure on the ground other than installation of an onboard unit in each vehicle, which would typically consist of a GPS receiver and a mobile communication device. In 2005, Germany adopted a distance-, place-, and emission-based pricing system for all heavy-duty trucks operating on its 12,000-kilometer national highway system, but there are no time-of-day congestion charges involved. The Netherlands is in the process of developing a national time-, distance-, and place-based pricing system for its entire street and road network.
- *Cordon pricing:* Under this system, a fee is charged every time a vehicle crosses a boundary (i.e., cordon) into and out of a charged zone. Generally, the charge varies between weekdays and weekends and peak and off-peak hours. Journeys that begin and finish entirely within the zone are not charged. Although cordon pricing can significantly reduce congestion, it can be viewed as unfair to travelers who must travel in and out of charging zones many times each day (e.g., taxis). Furthermore, because drivers who travel entirely within the cordon area (without crossing its boundaries) are not charged, those subject to the charge may perceive it as unfair. Stockholm has recently implemented a cordon pricing system.
- *Area-license systems:* This tolling system is similar to cordon pricing except that it allows drivers to make an unlimited number of journeys into and within a zone during certain hours for a fixed fee. Residents who live within the zone and therefore require a license may receive a discount. While area-licensing systems may be perceived to be fairer than cordon systems, they may be less effective at reducing congestion, since the charge does not vary with the number of trips into and out of the charging zone. Singapore had an area-license system from 1975 until 1998.[2] More recently, London adopted an area-license system in its downtown core.
- *HOT lanes:* HOT lanes are a version of high-occupancy vehicle (HOV) lanes, which have been introduced on highways in the United States to encourage ride-sharing during peak

[2] Starting in 1998, Singapore adopted a more extensive congestion pricing system that combines aspects of multiple forms of congestion pricing. Since then, it has gradually introduced tolls at 70 charging spots around two urban cordons and on arterial roads and motorways across the metro area. Toll levels vary by time and location to ensure that traffic is free-flowing at least 85 percent of the time.

periods. Under HOT-lane pricing, qualified carpool vehicles can use HOT lanes for free or at a discount while vehicles having fewer occupants may access the lanes by paying a toll. All vehicles continue to have the option of traveling in parallel, free, general-purpose lanes. In some cases, new HOT lanes have been installed as additional capacity. In other instances, existing HOV lanes have been converted to HOT lanes. In the United States, HOT lanes have been implemented in San Diego (Interstate, or I, 15); Orange County, California (State Route, or SR, 91); Minneapolis (I-394); Houston (I-10, on a stretch commonly known as the Katy Freeway); and Denver (I-25).

- *Toll roads, bridges, and tunnels:* In this case, tolls are applied independently to individual routes. In practice, these facilities often collect tolls to repay bonds issued to finance their construction rather than manage congestion. Tolls can be collected manually at toll-booths or electronically using transponder technology. Some highways with tolls vary the charge based on where the vehicle enters and exits the highway. Toll roads, bridges, and tunnels are not considered forms of congestion pricing unless tolls vary with congestion levels and serve to manage congestion. Examples of tolled facilities with time-varying tolls include a number of bridges and tunnels into New York City; the Dulles Greenway outside Washington, D.C.; the 407 express toll route (ETR) in Toronto; and some French autoroutes.

The adoption of different forms of congestion pricing varies dramatically between regions of the world. In Europe, cordon pricing and area-licensing systems[3] have been the most common type; in the United States, HOT-lane pricing has received greater attention. A number of reasons might explain the regional preferences for one type of system over another, including local government structures, existing land-use patterns, and the prevalence and use of public transportation.

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[3] Although the differences between these two systems were explained earlier in this chapter, in the rest of the report, we use the general convention of referring to both types of systems as *cordons*, since they share the idea of paying within a bounded area.

CHAPTER TWO

Defining Equity

To some, it seems only fair that motorists should pay for costs they impose on others, and a congestion toll is the most direct method of accomplishing this. To others, congestion pricing represents a form of taxation that is likely to harm disadvantaged members of society. While both perspectives are valid, they imply different perspectives on equity. They illustrate some of the difficulty involved in evaluating congestion pricing—namely, that many legitimate and conflicting notions of equity exist. This is compounded by the fact that there are numerous impacts to consider, many of which are difficult to measure, and there are many ways to categorize or group winners and losers (Litman, 2007). No accepted and widely used manual exists for assessing equity for transportation project evaluations, let alone for congestion pricing.

In this chapter, we highlight the notions of equity that often arise in the context of congestion pricing. We begin by defining some key terms in the equity debate. Next, we define several notions of equity that have been referenced extensively in the literature. We then describe different approaches adopted by transportation economists and planners for evaluating equity and discuss how they can be understood in a common framework. We end this chapter by describing some issues that arise when evaluating equity in congestion pricing.

Defining Key Terms Related to Equity

To discuss equity, we have to first understand what exactly is meant by the various terms used in the equity literature. *Equity* means different things to different observers, in part because the very concept of equity can be multifaceted (Ungemah, 2007; Viegas, 2001). Here, we define the word *equity*, which has a specific meaning in economic analysis, as well as other related words we use throughout this report.

Equity. Equity is concerned with the distribution of costs and benefits among members of society. Such benefits and costs—whether monetary or nonmonetary—can be distributed in ways that people may see as reasonable or unreasonable, depending on a variety of criteria that we discuss later. In this report, we use the noun *equity* in this objective sense of distributional criteria.

Equitable. A policy can be called equitable if it meets a normative standard of fairness. We recognize that these terms are somewhat confusing, that *equity* implies an objective analysis while *equitable* implies a subjective element, but this reflects the common usage of both terms. Of course, this implies that one observer may find a policy equitable while another does not, depending on the set of criteria applied. But this reinforces one of the main findings of

this report: that no policy can be definitively termed *equitable*; whether a policy is equitable depends on the criteria being applied.

Equality. Equality means that costs and benefits are distributed in a manner that benefits all people to the same extent. We can refer to equality of opportunity (all people have the same chances) or equality of outcome (all people end up with the same opportunities). One important distinction is that distributions can be equitable without resulting in equality. A tax, for example, might be viewed as equitable if higher-income groups tend to pay more than lower-income groups, because they are better able to afford the higher payment.

Efficiency. The term *efficiency*—sometimes called *Pareto efficiency* by economists—deals with the way in which resources are allocated in the economy. An allocation of resources (e.g., an assignment of motorists to different roads coupled with a taxing system) is deemed efficient if there is no other feasible allocation of resources that can make some people better off without making anyone worse off.[1] For most normative transportation analyses, however, the definition of *efficiency* is measured in terms of a policy's ability to maximize aggregate social welfare, regardless of whether some individuals are made worse off.

Welfare. In economics, *welfare* refers to the overall well-being of people, either as individuals or collectively. To measure welfare, economists generally add up the costs and benefits of a policy to determine whether individuals are better or worse off with the policy in place. Because some of these costs and benefits are not initially measured with money (such as time savings or improved air quality), welfare-based studies generally *monetize* these nonmonetary benefits or costs so that they can be compared and aggregated to measure welfare.

Aspects of Equity

The concept of equity can be applied in a number of ways. This section looks at several common aspects of equity studied in the congestion pricing literature. These notions of equity tend to imply a comparative assessment of one policy against some benchmark. Typically, the status quo policy in the jurisdiction under study is used as the benchmark for equity evaluations.

While the aspects of equity described in this section can be precisely stated, ultimately, to call one policy or set of outcomes more equitable than another requires that one impose some preferences on the way in which benefits and costs are allocated within society. These preferences embody how the evaluator values and is willing to trade off net benefits or costs that accrue to different members of society.

Horizontal Equity

Horizontal equity is concerned with how individuals from the same group (e.g., the poor, elderly) fare relative to one another. A policy is horizontally equitable if similar individuals are provided with equal opportunities or are made equally well off under the policy. Horizontal equity is related to the belief that all people in a given group are equal and should enjoy equal social, political, and economic rights and opportunities.

[1] This can result in a range of allocations that are considered efficient, all of which lie on what economists call the *Pareto-efficient frontier*.

Vertical Equity

While *horizontal equity* implies similar distribution of costs and benefits to individuals within a group, *vertical equity* refers to the distribution of costs and benefits across groups. The vertical-equity concept often differentiates between groups based on ability to pay, which is typically measured by an individual's income or wealth.

Some studies have attempted to tackle the vertical-equity issue by analyzing how *regressive* or *progressive* congestion pricing is relative to other public financing systems. As an example, a uniform tax[2] of $500 is regressive, since $500 is a larger proportion of a lower income.[3] Conversely, taxes that impose a higher burden on higher-income taxpayers (such as the U.S. income tax) are considered progressive. Economists have extended these definitions to include other monetary and nonmonetary benefits and costs induced by such policies as congestion pricing. A policy is progressive or regressive if it favors or burdens, based on some measurable criteria, disadvantaged individuals relative to others. While these costs and benefits are often expressed in monetary terms, they could be measured in other ways as well.

Because congestion pricing produces travel benefits and affects behavior, other nonmonetary benefits and costs need to be integrated into assessments of vertical equity. For example, consider the extreme hypothetical situation in which tolling prices all low-income users off the roads. In this case, tolling will be viewed as progressive when only the incidence of toll payments is considered, since only higher-income members of society end up making the payments. Clearly, this is misleading, since the cost of being priced off the road has not been incorporated. As discussed in Chapter Three, economists have developed methods for monetizing nonmonetary benefits and costs for the purposes of looking at the distributional implications of adopting congestion pricing.

Other Notions of Equity

Some objections to congestion pricing stemming from concerns over equity do not fall neatly into the categories outlined in the preceding section. For instance, it has been claimed that congestion pricing is a form of *double taxation* because, in many cases, road infrastructure has already been paid for with gasoline tax receipts. Charging a toll to use the roads would essentially force residents to pay for something they have already purchased. Critics of this assertion emphasize that, while the infrastructure may have been paid for by gasoline taxes, road use creates other costs for society—such as those stemming from congestion and pollution—for which the driver has not paid.[4]

To avoid concerns over double taxation, it has been proposed that gas taxes already paid can be tallied separately and reimbursed to drivers, as is already done for toll-road users in a few states (FHWA, 2006). Alternatively, this objection can be addressed by building revenue

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[2] *Uniform* means that all persons are treated equally with respect to an amount of money. A uniform tax would charge each person the same amount, and a uniform redistribution of revenues would provide each person with the same amount of money.

[3] In the public-finance literature, a tax is (1) *absolutely regressive* if the tax payments fall with income, (2) *average regressive* if taxes paid as a share of income fall, and (3) *marginally regressive* if the marginal tax rate falls with income.

[4] Furthermore, at the national level, the motor-fuel tax, which is levied on a cents-per-gallon basis and serves as the principal source of financing for highways, bridges, and transit projects, has not been raised since 1991. Inflation and improved fuel economy have combined to erode the value of this revenue stream in the intervening years, and the proceeds of the tax in real revenue per vehicle-mile traveled (VMT) are now far below levels of the early 1950s (Sorensen et al., 2008).

neutrality into the congestion pricing proposal—for instance, by lowering fuel taxes based on the amount of congestion revenues raised or earmarking the toll revenues for other investments that will benefit road users (Lindsey, 2007).

Another relevant notion of equity focuses on the amount that people pay relative to one of two factors: the costs they generate or the value of the benefits they receive. In the first of these notions, tolls are considered fair if people pay an amount roughly equal to the costs they impose on others. In environmental economics, this is called the *polluter pays* principle (see, for example, Lange, Vogt, and Ziegler, 2006). For example, a vehicle that pollutes more than average would cost more to drive than a clean car. These cost-based policies allow the government to make the rest of society whole; in this case, the revenues raised by highly polluting vehicles could be spent on air-quality improvements. This notion of equity conforms to the underlying principles of congestion pricing (see Chapter One).

The second of these ideas is known in public finance as the *benefit* principle: It is equitable for one group to pay higher taxes if its members receive greater benefits. Congestion pricing policy should perform favorably on this definition of equity, since, generally, those who benefit most from reduced congestion tend to pay more in congestion fees.

Some notions of equity combine aspects of both horizontal and vertical equity. For instance, when evaluating equity, some studies have differentiated between otherwise similar groups based on where they live or work. This has given rise to the notion of *spatial equity*, which can be viewed as a geographic application of the horizontal and vertical equity concepts. Similarly, *intergenerational equity* deals with the burdens placed on future generations by the current or past generations. This notion of equity is often discussed in the climate-change debate, which is, in turn, relevant for congestion pricing because it has the potential to affect vehicle emissions. Few researchers, however, have discussed intergenerational equity in the context of congestion pricing policies.

Criteria for Evaluating Equity

Transportation economists and planners have used a variety of criteria to evaluate the various notions of equity. Economists tend to use welfare-based measures based on microeconomic theory to characterize the impacts of adopting new policies, such as congestion pricing, while transportation planners and other social scientists tend to evaluate congestion pricing in terms of social justice, which includes transportation-accessibility and environmental-justice criteria.

Welfare-Based Measures of Equity

Studies that use a welfare approach to evaluate equity attempt to understand how policies affect the well-being of specific individuals, after taking their choices into account. They do this by quantifying the various benefits and costs that accrue to different individuals or groups from adoption of such policies as congestion pricing. The range of benefits that might be evaluated include improvements in travel speeds, reductions in expenditures on fuel and other vehicle-operating expenses, reduced crash risk, and reduced pollution and noise. The costs considered can include the cost of spending money on the congestion charge (as opposed to other goods and services) as well as the cost associated with reducing the amount of travel, traveling via other modes, or departing at different times. Additionally, the economics literature has

emphasized that benefits generated by investing or redistributing the tolling revenues should be included in evaluations of equity.

While no study is able to estimate the entire range of conceivable costs and benefits that might be generated by congestion pricing, some come closer than others. The most basic studies consider only the incidence of toll payments (i.e., which groups pay how much). Other studies compare toll payments as well as impacts on travel conditions and behavior. More-sophisticated studies go one step further by embedding congestion pricing in a public-finance framework in which impacts stemming from the use of congestion tolling revenues can be considered.

In theory, a welfare-based approach can be used to evaluate many different notions of equity, including horizontal and vertical equity. The use of this approach is not without drawbacks, however. The approach is often carried out using sophisticated models applied to hypothetical situations that incorporate tolling. Few analyses are based on data obtained from actual congestion pricing implications. As a result, it is difficult to verify the accuracy of most models used to evaluate congestion pricing. Furthermore, to keep the models from becoming intractable, analysts generally incorporate many assumptions that critics deem questionable.

Transportation Access

In the planning literature, a number of papers have assessed whether congestion pricing is equitable in terms of its effect on the ability of transportation-disadvantaged individuals or groups to participate in life activities, such as jobs, medical care, education, and shopping. While the term *transportation disadvantaged*[5] has no precise definition, the general consensus is that people may be transportation disadvantaged for a number or combination of reasons: low income, ethnicity, disability, family status, age, or gender (Rajé, 2003). At a societal level, whether individuals are transportation disadvantaged also depends on the availability and cost of public transportation. There is concern that people for whom paying congestion charges is a financial hardship may find their access to employment, places of worship, shopping, and visiting friends and family even more limited than it currently is.

These concerns center on ways in which increases in the monetary cost of driving will affect the opportunities of transportation-disadvantaged people to participate in social and economic activities. When transportation-access issues arise from congestion pricing, they are often tied to affordability. Essentially, in the language of the welfare-based measures, the question is how to assign a value to the cost of not being able to afford a trip or of having to spend more of their limited income to maintain essential travel.

Transportation access clearly has a spatial component, in that lower-income people may have very different travel needs depending on whether their neighborhoods are well served by transit or allow for daily needs to be met through walking. Depending on the distribution of low-income individuals and jobs in a region, if many low-income people have no choice but to drive to work during congested times, this has a different equity implication than if those jobs could be reached on transit.

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[5] The term *socially excluded* is also widely used for the same concept, particularly in the European literature.

Environmental Justice

Environmental justice is concerned with minimizing health and environmental effects on disadvantaged populations. Research in this field asks whether implementing congestion pricing would help alleviate some of the negative environmental impacts on low-income and minority communities, which, in some cases, are severe (for an overview of environmental justice and transportation, see Schweitzer and Valenzuela, 2004). Promoting equitable outcomes in this respect would mean that disadvantaged neighborhoods would experience an improvement in environmental impacts.

Measuring environmental impacts can be difficult for technical reasons; for example, depending on weather and climatic conditions, a reduction in emissions may or may not translate into a measurable reduction in pollutant concentrations. Translating environmental changes into a measure of how disadvantaged groups are affected can also be complex; for example, it may be difficult to definitively link a reduction in pollution with a reduction in asthma or other diseases.

Comparing Welfare-Based and Social-Justice Conceptions of Equity

In our review of the literature, we found that welfare-based and social justice–based assessments were often conducted using different tools and approaches and often without reference to one another. Litman (2007) suggests a framework for thinking about these seemingly different strands of literature. In Litman's framework, the evaluation of equity has four dimensions:

- *horizontal* versus *vertical equity* (as discussed earlier)
- *division of individuals into groups:* While, in many equity analyses, this is done by income, groups can be constructed along different demographic lines (neighborhood, gender, race, age, household size, and occupational status, among others).
- *measures of equity:* Some studies may assess only congestion charges paid, while others may incorporate benefits stemming from travel time savings or the costs associated with a reduction in trips, and so forth. Researchers may also differ in how they choose to value and compare nonmonetary benefits and costs.
- *degree of aggregation:* This refers to whether a study evaluates costs and benefits for specific groups of individuals or sums them across groups.

This shows how the disparate types of analyses found in the literature can be put into a common framework. Many formal economic analyses, for example, incorporate vertical equity, use income as the basis of groups, and look at the incidence of congestion charges plus the value of travel time saved and the benefits from revenue redistribution on a per capita basis. Some transportation access studies assess vertical equity but look at groups based on a definition of who is transportation disadvantaged (which is generally broader than income alone) and perform measurements that incorporate the cost of not being able to make trips they previously made because they have become too expensive. These analyses may reach very different results, but using such a framework allows us to see systematically how defining these dimensions affects the outcome.

Nevertheless, conflicting conclusions cannot always be easily resolved in a mutually satisfactory way because of the subjective aspects embedded in any determination of whether a policy is *equitable*. Litman (2007) highlights this. He suggests that the problem is not in failing to use the right approach but that differences in conclusions about equity stem from

the fact that the approaches employ different, yet legitimate, ways of defining and assessing equity. This clearly complicates the evaluation of equity and makes any assessment subject to qualification.

Politically, this is why equity evaluations for congestion pricing can be such a thorny topic: People debate the issue using the term *equity*, but they mean fundamentally different things because they have approached the issue using a different set of criteria. Therefore, as an observer attempting to sort out different equity evaluations, one needs to be cognizant of the variety of perspectives and approaches that are used to evaluate equity and may result in different conclusions.

Litman (2007) addresses this problem by noting that it falls to each community to determine appropriate criteria for evaluating equity. We can see the practical consequences of this recommendation in the different ways in which cities with congestion pricing have chosen to modify their programs to address equity concerns (see Chapter Four).

Other Difficulties in Evaluating Equity

As the preceding discussion suggests, the way in which the distribution of benefits and costs is measured, as well as people's preferences for different outcomes, can be evaluated in a variety of ways. When applied to congestion pricing, the difficulties can be even greater than for other forms of taxation, since the range of impacts it can produce is quite large. Some of the issues that complicate the evaluation of equity for congestion pricing policies merit discussing before we end this section. They include the following:

- *differences in context:* Unlike many other taxes or fees, the incidence of congestion pricing depends very heavily on location. People in the same income groups may experience congestion pricing very differently depending on where they live, work, shop, and worship. Another major factor is the presence, cost, and convenience of alternatives to driving; if people can easily switch from driving during congested hours to riding transit or walking, that has different equity implications than if such options are infeasible. For this reason, it is essentially impossible to compare the equity of congestion pricing as implemented in one city to another because so many other factors play a role in the outcomes. This makes the study of real-world equity issues very difficult; what is true in London or New York may not be true in Phoenix or Pittsburgh.
- *dependence on models:* Because of these contextual differences, most studies of congestion pricing rely on computer models rather than observed outcomes. Models in this field are highly sophisticated and can incorporate a wide variety of information, such as population demographics, travel patterns, and transportation-network features (e.g., road capacity, presence or absence of public transportation). They are used primarily to forecast the impact of different transportation policies and investments on traffic conditions. They are generally not designed to conduct evaluations of impacts on specific subgroups of the population, although many have attempted to use them in this way for the purposes of assessing equity.
- *assumptions about the value of nonmonetary benefits and costs:* One of the main assumptions in both models and their conclusions about welfare is how people value their travel time—how much they would pay to save a minute or an hour when they would other-

wise be stuck in traffic. The outcomes of travel-time analyses can vary depending on two factors. The first, the amount of time saved, is relatively easy to measure; the second, the cost of travel time, must be inferred rather than directly measured. While it is outside the scope of this report to review the many studies on measuring the value of travel time, modelers are reaching agreement that travel time is more complex than originally assumed: It not only takes into account prevailing wage rates but also differentiates based on trip type and therefore varies not only from person to person but also from trip to trip (Small, Winston, and Yan, 2005). Issues with valuing travel-time savings are similar to those that arise with respect to other nonmonetary benefits and costs, such as the value of a forgone or additional trip, an accident, or changes in pollution and noise levels.

- *comparisons between forms of transportation finance:* Finally, equity impacts depend on how congestion pricing is integrated into the larger system of financing transportation. Determining the equity of existing transportation policies, such as who pays how much toward road and transit investment and upkeep in the current system, is not simple. In addition, the differences in transportation-finance approaches adopted by local, state, and national governments make it difficult to compare equity outcomes of congestion pricing across regions.

CHAPTER THREE

Evaluating Equity

In this chapter, we present evidence of the equity implications of adopting congestion pricing policies. The evidence comes from two sources: studies of regions where congestion pricing has been implemented, and theoretical work on equity, either where congestion pricing has been proposed or for hypothetical systems.[1] While we emphasize work based on existing congestion pricing programs, the small number of extant programs means that some reliance on models and notional systems is necessary.

This chapter draws mostly on objective studies rather than subjective ones. As a result, we are better able to comment on equity (the distribution of costs and benefits) than on whether certain policies are more or less equitable than others. We do this for three reasons. First, public opinion is apt to change. Indeed, public-opinion surveys before and after congestion pricing has been implemented have shown substantial changes in opinion, generally from negative to positive (Glaister, 2007; Hugosson, 2007). While this may be good news for those who support congestion pricing, the fact that people have changed their opinions does not mean that the underlying patterns have become more equitable. Second, people's lack of approval may stem from a variety of factors, such as skepticism about the effectiveness of congestion pricing, not only equity. Third, rather than interjecting a particular set of values, we simply want to present the evidence on who benefits and who loses when different forms of congestion pricing are adopted. It is ultimately up to the users of this information to draw conclusions about whether a particular implementation of congestion pricing is equitable.

This is not to say that surveys and focus groups to determine public opinion about congestion pricing are unimportant. Indeed, understanding how the public or specific constituencies will react to congestion pricing is extremely important in developing proposals that will address distributional goals as well as command popular support. However, this report is more concerned with measuring equity than determining how the public perceives equity, a topic that is treated extensively elsewhere.[2]

Discussions of equity generally concern some type of comparison. We have organized this section around three key questions, all involving comparisons:

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[1] We reviewed a wide variety of studies in preparing this report, drawn (as noted earlier) from both economic and planning literature. Not all of them are included in this section, in some cases because their conclusions were better made in other studies and in some cases because we decided that the methodologies or data were not adequate to the task. However, we attempt to give a sense of the development of this field as well as the latest findings. We emphasize several studies whose findings we found particularly solid and mention in passing others whose contributions are relevant but tangential. Our analysis was limited to a review of studies written in English.

[2] For a review of public-opinion surveys on congestion pricing, see Zmud and Arce (2008); for insight from transportation planners on how equity concerns play out during project planning and implementation, see Weinstein and Sciara (2006).

- What are the equity implications of congestion pricing relative to those of current transportation policies for addressing congestion concerns and financing transportation improvements?
- What are the equity implications of different forms of congestion pricing relative to one another?
- Is there variation in equity outcomes within forms of congestion pricing systems?

Our analysis begins with the broadest dimension of assessment and continues through narrower questions of whether there are equity differences between forms of congestion pricing and then within particular forms. In each case, we discuss the different aspects of equity outlined in Chapter Two.

Because of the breadth of this topic and our focus on objective assessment, several topics related to equity and congestion pricing are not addressed here. The following list notes which topics we did not include:

- First, we found no studies that looked at equity impacts from congestion pricing in terms of vehicle crash rates and noise, so these potential impacts are not discussed.
- Second, while there is a small body of literature describing how congestion pricing affects retail outlets and other businesses (London Chamber of Commerce and Industry, 2005; Lagerén and Sandahl, 2007; Quddus, Carmel, and Bell, 2005), we choose to focus our attention on individuals. At least in the United States, the debate over equity has been more focused on how congestion pricing might affect individuals than on the implications for businesses. This is not to say that the consequences of congestion pricing on businesses do not matter; certainly, the "boundary effects" of cordon pricing can affect patrons' ability to access businesses. However, a number of factors affect business trends, and retailers may single out congestion pricing for declines in business patronage or sales when other factors are at work.
- Third, there are few equity studies of congestion pricing and long-term impacts, such as the possibility that congestion pricing may induce changes in land-use or population patterns. While it is conceivable that such patterns could change as a result of congestion pricing, so many other factors are simultaneously at work that they become difficult to assess with any accuracy. While congestion pricing may well contribute to long-term trends, especially if it is used as a tool to promote land-use patterns that broadly support transit, we were unable to identify many studies that convincingly linked congestion pricing to long-term land-use changes.[3] In this respect, it is unfortunate that long-term studies of congestion pricing with regard to equity in Singapore do not exist, as Singapore has a longer history with congestion pricing than any other region. On the other hand,

[3] We located three studies that dealt with long-term impacts. Löchl (2006) provides a summary of the existing literature in this area. His review suggests that road pricing will have a centralizing effect for residential land use, while the spatial effects for firms are less certain. His study did not, however, deal explicitly with the equity impacts associated with induced land-use changes. Another modeling exercise of a variety of transportation and land-use policies, including pricing, in several European cities concluded that "[d]ifferent car pricing methods [road and parking pricing] were able to produce positive results [on a variety of environmental and social indicators]. However, their effects on land use have to be separately assessed" (Lautso et al., 2004, p. 4). Safirova, Houde, Coleman, et al. (2006) model changes in real-estate values and the residential patterns and do discuss the distributional implications of congestion pricing. We discuss this study later in this chapter.

economic conditions have changed so dramatically in the 30-plus years that congestion pricing has been in place,[4] and the national government has so heavily invested in transit and transit-oriented development, that it would be difficult conceptually to tease out the impacts of congestion pricing.

- Finally, while this report looks at congestion pricing compared to existing approaches to managing congestion and financing improvements, it does not examine in detail how congestion pricing might act as a complement or substitute for other approaches to providing transportation access, particularly road-building and public-transportation investments. Conceptually, this is a difficult area in which to perform rigorous analysis, and there are limited findings on which we can draw.[5] There is a growing body of literature on the overall impact of road building and, in particular, its negative effects with regard to environmental impacts and induced travel demand (see, for example, Noland and Lem, 2002, and Cervero, 2002). A synthesis of 40 scenario-based regional modeling studies in the United States and European Union by Johnston (2006, p. 1) concluded that reduced-VMT scenarios that involved less road investment, more transit investment, and increased charges for road users "generally produce higher transportation system productivity, positive net user economic benefits, greater equity in the distribution of transportation system benefits, reduced congestion delays, and a reduction in other adverse environmental impacts." The effects of more general patterns of transportation investment and policy on the equity impacts of congestion pricing would benefit from additional research.

Comparing Congestion Pricing to Current Transportation Policies

In the following discussion, we summarize the literature that deals with the distributional implications of adopting congestion pricing. Many of these studies also consider the way in which revenues raised from congestion pricing are utilized. As mentioned in Chapter Two, many of the studies that evaluate the adoption of congestion pricing take as their reference point the current policy in place in the area under study. Because local circumstances vary so dramatically, it is difficult to generalize many of these findings.

With regard to transportation finance, it is complicated to assess how adding congestion pricing changes the equity picture because it requires assessing the impact of other taxes it might offset or new investments it might support. For example, congestion pricing could be *revenue neutral*, which means that it would entirely replace an existing revenue source (e.g., the local sales tax would be lowered by an amount equivalent to what would be raised by congestion pricing), or it could constitute an additional source of funding, allowing the government to expand its budget and make additional investments. Given that, the overall picture of how much transportation funding comes from various sources differs not just from country to country but, in many cases, from county to county. Such assessments are extraordinarily complex and not generalizable to other contexts.

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[4] As one example, per capita income in constant 1995 U.S. dollars increased from $5,600 in 1972 to $22,800 in 1995 (Willoughby, 2000).

[5] The one equity study we found comparing the two, on the environmental impacts of congestion pricing and road building, is Tonne et al. (2008), discussed later in this chapter.

As described in Chapter Two, the literature that looks at congestion pricing vis-à-vis existing transportation systems tends to use three different and distinct criteria: welfare, transportation accessibility, and environmental impacts. We cover each of these here.

Welfare-Based Evaluations of Equity of Congestion Pricing

The studies that we reviewed that take a welfare perspective can be thought of as lying along a continuum of increasing analytical complexity. Some look only at fees paid, while others incorporate other travel costs and benefits (e.g., reduced trips, improved travel times). Still others go further by dealing with different mechanism of revenue redistribution. The latter provide the truest picture of who benefits and loses when congestion pricing is implemented, but they also depend on greater analytical complexity and assumptions.

For studies that look only at the payment of fees, the general conclusion is that congestion pricing is slightly regressive but less so than other forms of taxation, such as a sales or gasoline tax. Lee (2003, pp. 49–50) notes that "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 [these forms of taxes] on vertical equity grounds." Schweitzer and Taylor (2008) looked at the difference in tax incidence between paying off an existing bond with toll revenues or sales-tax revenues and found that the lowest and highest income quintiles pay more with a sales tax than a toll. The middle quintiles "fare much better under a general sales tax than under a tolling scheme, because they are the heaviest users of the facility" (p. 805). Cain and Jones (2008) found that, for vehicle-owning households, current spending on both driving and congestion tolls were regressive. We did not identify any studies that specifically compared a fixed-toll policy to one that varies tolls with congestion levels.

Studies that consider travel impacts can vary in their conclusions depending on assumptions related to a number of factors, including motorists' value of time and forgone trips. When fees paid and changes in other travel behavior and conditions are taken into account, most researchers have found that lower-income drivers fare worse under congestion pricing systems than under the status quo policy because they may have limited flexibility in their travel behavior and the congestion tolls may pose a financial hardship relative to the value of any travel-time savings that might be enjoyed. Anderson and Mohring (1996, p. 38) find that "low income travelers would have the worst of all worlds [with congestion pricing, as] their time plus money costs of travel would almost double," but this would be true only if low-income travelers continue to drive and not change mode, departure time, or number of trips.

Studies that attempt to assess the broader set of benefits and costs from congestion pricing—including those tied to revenue redistribution—suggest that the way in which toll revenues are spent can have a large effect on who benefits and who loses from congestion pricing. Studies have found that congestion pricing can promote more desirable distributional outcomes when revenues are redistributed to those who pay tolls. However, the details of how to achieve such redistribution schemes in a real-world setting are not usually explored in these papers.

Early theoretical studies of the distributional effects of congestion pricing include Richardson (1974), Leuthold (1976), and Layard (1977). Small (1983) assessed the impacts of congestion tolls on different income groups under alternative revenue-redistribution systems. Without redistribution, tolling tends to benefit higher-income individuals. The redistribution of revenues, however, can help improve outcomes for lower-income groups. For instance, revenues

can be used to support programs that primarily benefit low-income individuals or to reduce other regressive fees or taxes. Arnott, de Palma, and Lindsey (1994) analyzed the distributional effects of congestion pricing in a model assuming that users vary in their cost of schedule delay and value of travel time. They find that, with uniform, lump-sum revenue redistribution back to toll payers, congestion pricing tends to be regressive.

Eliasson and Mattsson (2006) studied the impacts of revenue distribution in the Stockholm congestion pricing trial. They looked at groups based on gender, income, household type, occupation, and neighborhood and four possible ways to redistribute revenues: lump sum, transit investments, reductions in driving costs, and decreases in income tax. With respect to income, they found that the highest of the three income groups reduced their trips the most and paid the highest charges. The impact of the increased charges plus the value of travel time was negative for all three income groups, with the greatest losses for the highest-income group. A uniform redistribution of revenues back to citizens produced progressive results, since the lowest-income group receives the same revenue-redistribution benefits as others but does not experience large losses. Transit investments were also found to be progressive, while across-the-board income-tax cuts were highly regressive. Policies that use the revenues to reduce the cost of driving were neither progressive nor regressive.

In a hypothetical study of cordon pricing in Oslo, redistribution based on personal income was regressive, while a uniform redistribution of revenues to citizens was progressive (Fridstrøm et al., 2000). A hypothetical study of revenue-neutral congestion pricing on a bridge in Washington State found that, with uniform redistribution of revenues to toll payers, pricing schemes were progressive relative to the current situation (Franklin, 2007).

An analysis of the proposal for cordon pricing in New York City suggested that it would be progressive. This conclusion was based on census data by borough and city showing that average incomes of driving commuters to Manhattan are usually (but not always) higher than those who commute by transit or other means and on recommendations to use revenues for transit and nonmotorized investments. However, the proposal did not present an analysis of toll payments and benefits by income group or estimate changes in travel behavior once the toll was implemented (New York City Traffic Congestion Mitigation Commission et al., 2007–2008). Other proposals about how to distribute revenues have been made but were not analyzed with respect to whether the results would be progressive or regressive (Small, 1992; King, Manville, and Shoup, 2007).

In one study that touches on land-use changes, Safirova, Houde, Lipman, et al. (2006) analyzed a downtown cordon system of Washington, D.C., using an integrated land-use, transportation, and economic model. When the distributional impacts are broken down for different income quartiles, the highest- and lowest-income quartiles tend to benefit most under a uniform, lump-sum redistribution scheme of the toll and transit revenues. Benefits to the lower-income quartile stem primarily from revenue redistribution, while higher-income individuals benefit from higher wages that stem from a reduction in the labor supply that, in turn, drives up wages.[6] They also found that those living in the downtown area and farthest-out suburbs benefit the least from cordon pricing, and therefore there is some very slight (less than

[6] According to the study, under the presence of a cordon toll, "the total number of employed individuals decreases across all quartile groups, creating a scarcity in the labor force and helping to drive the wage increases. This decrease in labor supply can be explained by the fact that the lump-sum redistribution of the toll revenue constitutes an increase in unearned income, decreasing the opportunity cost of unemployment" (Safirova, Houde, Lipman, et al., 2006, p. 16).

0.5 percent) population shift from the inner areas just outside the cordon either to downtown or to outer areas.

Small, Winston, and Yan (2006) studied HOT- and express-lane[7] pricing using a model estimated from data collected for SR-91 in Orange County, California. They find that, while the highest-income quartile tends to benefit more than the lower-income quartile, there is significant variation among winners and losers within each income quartile.[8] This is because, even when controlling for income, drivers vary in their preferences for travel-time savings and reliability. These findings highlight the fact that, while congestion pricing might make groups of individuals better off *on average*, it is unlikely that every person within a group is made strictly better off, since individual preferences can vary greatly.

Despite the findings of this research, some are skeptical about whether redistribution can have a significant impact on income-based equity concerns. "Since so many factors determine the impacts of congestion pricing, revenue redistribution cannot solve all equity and fairness concerns" (Giuliano, 1994, p. 275). "In principle, anyway, a system for redistributing this loot that would make everyone better off should be possible. Sadly to say, such a system has yet to be devised" (Mohring, 1999, p. 206).

Two caveats to this research are worth noting. First, Alan W. Evans (1992) points out that, since low-income groups are more likely to use public transportation, they will tend to be less affected by congestion charges and will benefit more than higher-income individuals when the toll revenues are used to improve public transportation. This argument is more relevant outside the United States, where public transportation is more widely used and accessible. Second, most studies analyze congestion pricing as an alternative to doing nothing (i.e., leaving roads untolled). The reality is that, without congestion pricing, the long-run need to build roads will be greater. So a more valid policy comparison might be between two means of dealing with congestion: congestion pricing or roadway-network expansion. However, as noted in the introduction to this chapter, we know of virtually no studies of this kind that have been conducted in the context of distributional outcomes.

Transportation Access

In contrast to studies concerned with welfare, the planning literature also contains discussion and analysis focused solely on individuals who are transportation disadvantaged. The main research question addressed by this strand of the literature is whether a congestion pricing system will make transportation access worse for the disadvantaged.

In comparing a transportation system with congestion pricing against existing transportation systems without it, researchers have found that many existing transportation systems do not work well for transportation-disadvantaged people. For example, in focus groups[9] conducted in Bristol, England, transportation-disadvantaged residents commented that transit is inconvenient. Existing transit routes did not serve their travel needs (the system was radial, but

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[7] Express lanes are similar to HOT lanes except that they require carpools to pay tolls.

[8] In Small, Winston, and Yan's study, toll revenues are assumed to be redistributed uniformly across individuals (both paying and nonpaying).

[9] While we do not cite studies that develop conclusions about equity based on public opinion, we include this discussion because it gets at how specific groups experience transportation. While we can develop reasonably objective measures of group welfare, it is difficult to develop measures of transportation access for individuals because so much depends on where people live and travel.

their needs were suburb-to-suburb, resulting in longer trips and higher fares), English-only signage was a barrier to those who do not read English well, and transit was perceived as unsafe (Lucas, Grosvenor, and Simpson, 2001; Rajé, 2003). As a result, people who could not drive or afford to own cars relied heavily on others to drive them, or they used taxis.

In stated-preference surveys of transportation-disadvantaged persons,[10] opinions about introducing congestion pricing were mixed. Some were "furious" at the idea, stating that their "quality of life would be seriously compromised" if driving became more expensive (Lucas, Grosvenor, and Simpson, 2001, p. 38), because they would have to forgo trips or pay more to take them. However, other research found that the transportation disadvantaged are open to congestion pricing, providing that the revenues are spent on lessening their current transportation problems. This is an important point; in the Bristol case study, a planned light-rail line that was perceived to serve wealthier communities was disparaged, while respondents were open to investments in demand-responsive service and new bus routes (Rajé, 2003).

The London congestion pricing system has been monitored extensively to determine whether these concerns have been realized, and, for the most part, they have not been. In the most recent monitoring report, focus groups and surveys were conducted of groups that might have been disadvantaged by the congestion tolls: households with low incomes, people with disabilities, and their caregivers. Low-income households and the disabled were more likely to find the charge "difficult" to afford than the general public (about 50 percent, as opposed to 30 percent of the general public). The rates at which groups changed their travel behavior, though, were more similar: About 70 percent of low-income households made fewer trips, as compared to 60 percent of all those surveyed (Transport for London, 2008).

Persons with disabilities can apply for an exemption from the charge, and about 80 percent of disabled persons interviewed reported no change in travel due to congestion pricing. Voluntary organizations continued to provide services at their previous rates. However, a small minority of disabled persons reported a negative change in response to congestion pricing—generally a reduction in weekday visits from friends and family.

As with many other aspects of congestion pricing, much depends on the specific situation in the region and how the program is implemented. For example, the evidence just described is based on area-license or cordon pricing systems. A HOT lane would likely have much less of an impact, since it does not present a stark choice between paying to drive and forgoing the trip or changing time, mode, or destination. Equity issues specific to HOT lanes are discussed later in this chapter.

Even researchers who support congestion pricing on the grounds that it produces more equitable outcomes acknowledge that some low-income drivers may be made worse off. For example, Schweitzer and Taylor (2009, p. 21) note that "[t]he out-of-pocket gain from voting for a sales tax rather than a toll would provide savings of up to $700 a year for heavy users in lower income groups—a sizable cost saving to those who would need the facility frequently during peak times." Cain and Jones (2008) found that up to 10 percent of households in the lowest-income quintile would be subject to hardship if a proposed cordon pricing system in Edinburgh had been implemented, even as other low-income households might benefit from

[10] *Stated preferences* are those that people claim to have when presented with hypothetical situations—for example, asking whether a respondent would stop driving to work if congestion pricing were implemented. *Revealed preferences* are those that manifest themselves once the change in situation has actually taken place (i.e., observing whether a person stops driving to work after congestion pricing is implemented).

increased transit investments. Chapter Four addresses ways to improve equitable outcomes vis-à-vis transportation-disadvantaged groups.

Environmental Issues

While the environmental-justice literature contains substantial work on the negative impacts of transportation on certain communities, particularly with regard to air quality (see the overview in Schweitzer and Valenzuela, 2004), the question of how introducing congestion pricing might affect these communities has not been widely studied. The two studies we identified showed a positive, but fairly small, impact on equity as measured by environmental impacts. Tonne et al. (2008) studied the impacts of changes in emissions on areas ranked from most to least deprived. They concluded that congestion pricing has a more pronounced positive impact on more deprived areas than on nondeprived areas but that the effect is very slight: The reduction in nitrogen oxide (NO_X) exposure, for example, would add 60 years of life per 100,000 people over a 10-year period.[11] A study of a hypothetical cordon pricing system in Leeds found that congestion pricing would benefit low-income city dwellers because it would reduce air pollution, whereas building new roads would increase inequitable environmental outcomes. However, doing nothing also reduced inequitable outcomes, albeit by a lesser amount, because of the change over time in the vehicle fleet to less polluting vehicles (Mitchell, 2005).

A number of studies have linked congestion pricing to reduced emissions (Beevers and Carslaw, 2005; Banister, 2008; Kockelman and Kalmanje, 2005; New York City Traffic Congestion Mitigation Commission et al., 2008; Chin, 1996; Deakin et al., 1996) but without reference to equity.[12] Where researchers have found an emission impact due to congestion pricing, it may have more to do with increasing vehicle speeds than reducing VMT (Beevers and Carslaw, 2005; Boriboonsomsin and Barth, 2007). With HOT lanes, physical configuration of the lanes may make a difference to environmental outcomes (Boriboonsomsin and Barth, 2008).

Whereas much of the literature looks at congestion pricing as a general concept or models types of systems that have yet to be implemented (Giuliano, 1994; Deakin et al., 1996), the remaining research focuses on specific forms of congestion pricing. The next section looks at how types of congestion pricing systems compare to one another, while the final section assesses how variations within those systems affect equity.

Comparing Types of Congestion Pricing Systems

In this section, we look at research on how different types of congestion pricing systems—cordon and area-license systems, HOT lanes, and distance-based systems—compare with regard to equity outcomes. Of course, it is difficult to compare systems empirically, since they are implemented in different contexts, so the evidence on these points tends to be more general and theoretical.

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[11] This works out to less than one day per person. To put this figure in context, a study of reducing the sulfur content of fuel found increases in life expectancy of 20 to 40 days for a one-year exposure period (Medley et al., 2002).

[12] Note that these studies all deal with conventional pollutants, not greenhouse gases. We did not identify any studies that linked congestion pricing specifically to greenhouse-gas emissions.

Several studies found that distance-based systems would produce better overall outcomes for low-income drivers than cordon systems would. Bonsall and Kelly (2005) compared two conventional cordon systems in Leeds (one having a downtown cordon, one having a much larger, metro-area cordon) with systems that charge fixed (i.e., they do not vary by time of day) distance-based tolls within the cordons. For their analysis, they set collected revenues equal for all systems. All four policies affected similar proportions of disadvantaged drivers: Seven to 9 percent of charged drivers were of low income, and 4 percent were disabled. While the average charge per driver was lower with the distance-based systems, regardless of the size of the cordon, about one-third of low-income drivers would pay more with a distance-based system than a conventional cordon, about the same proportion as drivers of all incomes.

Another study, of Oslo, that compared first-best congestion pricing[13] to a cordon with parking charges found a total welfare gain under the distance-based system almost four times higher than the total welfare gain from the cordon. In terms of equity, when revenues were distributed uniformly, the distance-based system was progressive, while, with the cordon system, results were neutral (Fridstrøm et al., 2000).

As part of Small, Winston, and Yan's (2006) analysis, they compared HOT- and express-lane pricing to a policy in which all lanes were priced. They found that pricing all routes tends to amplify losses for lower-income travelers, who are likely to place a smaller value on travel-time savings and reliability.

HOT lanes are generally considered (Richardson and Bae, 1998; J. Evans, Bhatt, and Turnbull, 2003) to have fewer equity impacts than other congestion pricing systems, because they do not remove options from drivers (i.e., people can continue driving in general-purpose lanes without paying any charges). However, this does not mean that every HOT lane can be assumed equitable; Weinstein and Sciara (2006, p. 182) state that their extensive research "does not offer unconditional judgment as to whether HOT lanes are equitable."

Comparing Ways to Implement Congestion Pricing Systems

Finally, the specific details of how congestion pricing systems are implemented can affect the equity outcomes. This section looks at cordon systems and HOT lanes to examine the degree to which equity depends on specific decisions. We did not identify studies that looked at distance-based or other types of systems in the same fashion.

Cordon Pricing

With respect to cordons, the definition of the tolling area relative to the spatial distribution of low-income neighborhoods can dramatically affect equity. As one study put it, "In urban areas, the relationship between gainers, losers and income will depend critically on where different income groups live in relation to the charging areas. This is likely to vary from place to place" (Parkhurst et al., 2006, p. 36). In a study of three hypothetical cordons in British cities, Santos and Rojey (2004) found that cordon pricing can be progressive, neutral, or regressive depending on how incomes are distributed in a region. The cordon pricing system proposed for New York City was found to be more equitable geographically than current tolls are, since it would

[13] First-best congestion pricing, as noted in Chapter One, is a hypothetical system in which each driver pays his or her entire cost, meaning that payments would vary directly with externalities generated by specific trips.

more closely align the proportion of drivers using the roads into Manhattan from various locations with the amount they pay (New York City Traffic Congestion Mitigation Commission et al., 2008). In Edinburgh, the proposed system would have exempted a more affluent neighborhood from payment because of the city's administrative boundaries, whereas an adjoining, less affluent neighborhood would have been subject to the cordon toll, an outcome that was deemed inequitable because it treated people living at equal distances from the cordon differently (Rajé, Grieco, and McQuaid, 2004). These examples illustrate that cordon pricing systems have special concerns in terms of the links between income and spatial equity.

Maruyama and Sumalee (2007) looked at differences between implementing a cordon system in which drivers pay every time they cross the boundary and an area-license system in which drivers pay once to drive within the cordoned area. The differences they found in social welfare and their measure of spatial equity (based on the Gini coefficient, which measures inequality) were less than 1 percent.

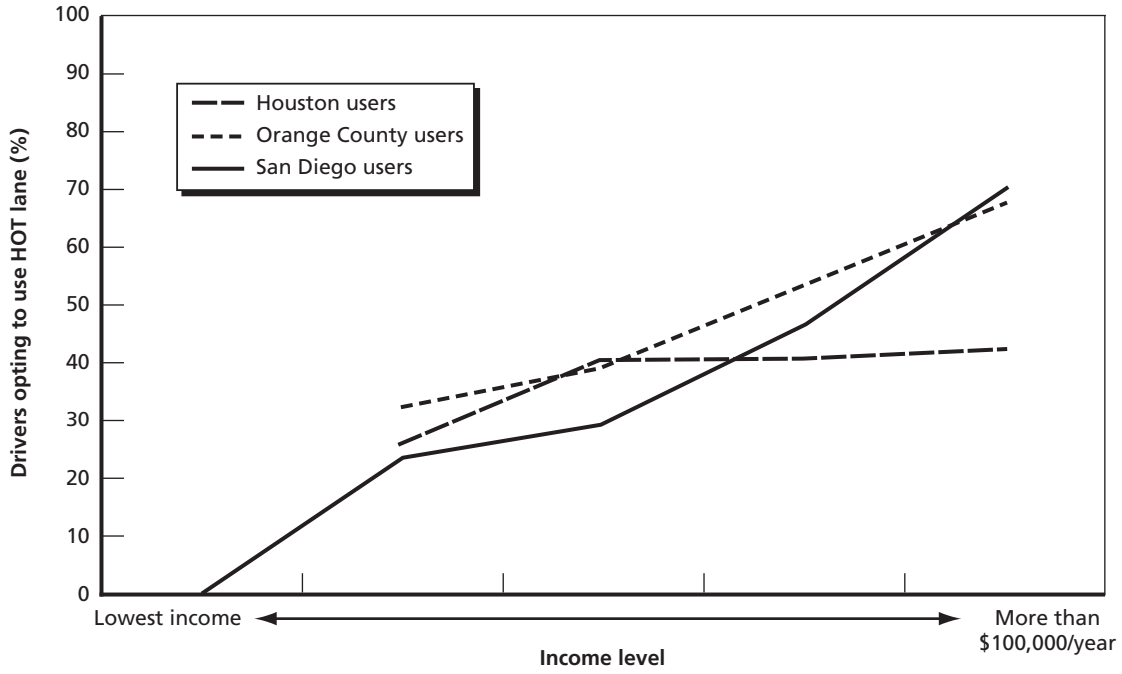
HOT Lanes

In this section, we address the equity implications of HOT lanes. As noted earlier, throughout this report, we consider equity outcomes of congestion pricing as compared to other transportation alternatives. For HOT lanes, the comparison implicit in most studies is that of the existence of HOT lanes on a particular corridor to the previous situation, in which all lanes were unpriced, and our conclusions flow from those sets of comparisons. We were unable to identify long-term, systemic comparisons of congestion pricing to road-building, so this section cannot address whether building new roadway capacity with priced lanes is more or less equitable than providing transportation capacity through other modes. Such a long-term comparison would be interesting and relevant, but, without published work on this topic, we cannot address it here.

One study indicated that, when HOV lanes were converted to HOT lanes, low-income long-distance carpoolers were made worse off because the fees paid were higher than the value of time savings and other benefits, even when redistribution was taken into account (Giuliano, 1994). Another study of the Washington, D.C., area looked at three scenarios: (1) adding new, tolled lanes and converting existing HOV lanes to HOT lanes; (2) all of scenario 1 plus tolling some existing urban lanes and bridges; and (3) all of scenarios 1 and 2 plus tolling existing parkways. The scenarios all included enhanced transit. The only equity measurement was access to jobs. All scenarios produced a gain for minority, low-income, and disabled populations in terms of access to jobs via transit. For highway access to jobs, scenario 1 produced gains, while 2 and 3 produced losses as well as gains, although generally the gains were larger (gains ranged from 9 to 18 percent, while losses ranged from 7 to 13 percent) (Eichler, Miller, and Park, 2008).

HOT-lane research on all four existing implementations in the United States has found that higher-income groups use the HOT lanes more than lower-income groups do (Patterson and Levinson, 2008; Burris and Hannay, 2003; Sullivan, 2000; Supernak et al., 1998). Figure 3.1 shows the percentage of people in different income groups who utilize the HOT lanes near where they live. For example, in Orange County, in the lowest-income group, only 30 percent use the HOT lanes, but, of those making more than $100,000, almost 70 percent use them. The figures are not directly comparable to each other, since not all the implementation details were the same, nor is income necessarily distributed similarly among users of the various corridors. On San Diego's I-15, at the time the survey was conducted in 1997,

Figure 3.1
Proportion of Users in Each Income Group Who Opt to Use the HOT Lanes in Selected Cities



SOURCES: Patterson and Levinson (2008), Burris and Hannay (2003), Sullivan (2000), and Supernak et al. (1998). Minneapolis data are not shown because Patterson and Levinson (2008) do not provide percentages of users by income group.

NOTE: Exact breakdowns of income are not shown because they varied between regions. However, in all cases, the highest-income group made more than $100,000. Data are based on surveys of residents who live near the corridor.

RAND *TR680-3.1*

drivers had to choose whether to purchase a monthly paper pass that admitted them to the HOT lanes; they could not decide on a daily basis whether to use and pay for the HOT lanes.[14] Orange County's SR-91 has such features as discounted tolls for vehicles with three or more occupants, an Express Club that assesses a flat monthly fee in exchange for discounts, and charges on low-activity accounts.

Since equity evaluations depend on comparing congestion pricing to some other condition, studying the usage of HOT lanes after they are implemented cannot directly address the equity question. We would note, however, that it is often true that low-income drivers are not a major share of peak-period traffic; in San Francisco, for example, only 5 percent of peak-period drivers earn less than $50,000 per year (Chang and Bent, 2009).

Compared to other types of congestion pricing, HOT lanes create far fewer implementation issues. There seem to be slight differences in equity outcomes among the four HOT lanes that have been implemented in the United States, but it is hard to say whether that is because of the way they are implemented or because of other factors. While the distributional impacts of HOT-lane pricing are likely to be less of an issue when compared with other forms of pricing, we discuss a few factors that are worth noting.

[14] I-15 now employs technology that allows users to make different choices each day.

First, all U.S. HOT lanes currently operate with electronic toll collection and require drivers to have transponders. If these systems were to require a credit card and bank account, many low-income users would be unable to participate. Estimates show that about 10 percent of the U.S. population does not have a bank account and that about 20 percent do not have credit cards, with these figures far higher among lower-income groups. Income has been found to have a positive impact on transponder ownership, suggesting that lower-income groups are less able to take advantage of HOT lanes (Parkany, 2005).[15]

Second, as with cordon systems, the spatial distribution of users plays a role in equity outcomes. In Minneapolis, where the I-394 HOT lane runs from a suburban area into downtown, people who lived farther from the city and had higher incomes paid more in tolls than those living closer in (Patterson and Levinson, 2008). If wealthier households tended to live closer to the city and pay less in tolls, vertical-equity impact might be a concern, since lower-income individuals who opt to use the facility will tend to pay more in tolls.

Third, HOT lanes tend to generate far less revenue than cordon pricing systems. If a HOT lane were to create distributional concerns, the revenues to address the imbalance might not be available. While some HOT lanes can raise substantial revenues, others do not. SR-91 netted $18.9 million in fiscal year (FY) 2007 (Orange County Transportation Authority, 2007),[16] whereas, in FY 2009, I-15 will provide only $500,000 to support transit in the corridor (Toups, 2008). (In contrast, the London cordon netted $211 million in FYs 2007–2008; see Transport for London, 2008.) HOT-lane revenues can also be undermined by the provision of parallel free capacity; the I-15 corridor previously earned revenues of up to $1 million annually, but the opening of a parallel free corridor reduced usage and revenues (Toups, 2008).

Finally, some analysts have raised concerns, claiming that, if HOT-lane revenues are used to expand the road network, they will harm the environment and equity by inducing more traffic growth and sprawl (Replogle, 2006; Litman, 2006). To our knowledge, no formal evaluation of these claims has been conducted in the context of currently implemented or proposed HOT lanes, suggesting that more study in this area is needed in the future.

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[15] Congestion pricing proposals that require motorists to purchase monthly passes would also tend to produce barriers to participation, especially since some drivers might want to use the lane only occasionally. We are not aware of any congestion pricing system currently in effect requiring monthly passes.

[16] Net revenues are calculated as total revenues minus operating expenses.

CHAPTER FOUR

Making Congestion Pricing More Equitable

As noted in earlier chapters, many of the equity implications of congestion pricing differ from place to place and with the form of congestion pricing considered. Furthermore, deeming one policy more equitable than another requires a value judgment as to how costs and benefits should ideally be distributed. As a result, it is difficult to make blanket recommendations regarding how to promote more equitable outcomes. Nevertheless, we do have a number of recommendations based on our findings that should help policymakers pursuing congestion pricing develop effective methods for addressing equity concerns.

This chapter discusses the methods that have been implemented to address equity concerns, as well as proposals documented in the congestion pricing literature that have not yet been implemented but are worth considering. In particular, we discuss how the planning process can be modified to more fully promote equitable outcomes when congestion pricing is being considered. We also review specific means of promoting equitable outcomes through revenue redistribution, discounts and exemptions, and other means. Where such measures have been implemented, we provide examples, although not an exhaustive list. Finally, the chapter ends with a discussion of the tensions that can exist between efficiency and equity goals and how they might be balanced.

Incorporate Equity Criteria in Planning

One effective way to identify and address equity concerns is to formally incorporate equity criteria into the planning process for congestion pricing projects. Ideally, this would begin early in the planning process, when strategies for addressing transportation goals and objectives are being formulated. As strategies are considered and developed, they should be evaluated in terms of both their ability to meet stated transportation goals and their impact on equity. The criteria used to evaluate equity should be made as clear as possible and shared with stakeholders as part of the outreach process.

Most congestion pricing proposals are studied using models. Modeling generally occurs after a broad range of strategies have been considered and some basic design features of the congestion pricing plan have been specified. Transportation planners use models to assess how congestion pricing and investment strategies are likely to influence congestion levels, travel patterns, and overall user impacts. Models can also inform discussions about how to set toll levels and how much revenue might be generated, where best to impose pricing, and

which infrastructure investments are most complementary to pricing.[1] In some cases, a formal benefit-cost analysis may be performed to help prioritize and rank different alternatives and ensure that the benefits of tolling justify the investments that will be required.

To address equity concerns in the modeling phase, modeling could potentially forecast how pricing affects the behavior and welfare of low-income and transportation-disadvantaged people. This admittedly can prove complicated, since few models link impacts to specific demographic groups. However, in the future, as models become more sophisticated, this type of analysis is likely to become more feasible. San Francisco, for example, used an activity-based model to analyze the potential impacts of congestion pricing by income (Chang and Bent, 2009).[2] In addition to tracking how pricing affects currently disadvantaged individuals, information from models can be used to identify groups that are likely to be made worse off by congestion pricing. This will give policymakers the information needed to develop more equitable congestion pricing strategies; for example, it can cause one to avoid drawing a cordon such that a low-income neighborhood is right outside it (Bonsall and Kelly, 2005).

For the present, without sophisticated travel-demand models that can identify potential equity concerns, a number of other means have been suggested for identifying and addressing such concerns early in project planning. Ungemah (2007, p. 16) suggests project-evaluation criteria for equity. Some suggested questions include the following:

> Are proposed toll facilities located in the areas of highest need? Are proposed facilities disproportionately influenced by potential cost recovery [i.e., it might be inequitable to build the most profitable project first, especially if others have greater benefits]? Are the distributions of benefits aligned with the principles of environmental justice? Are improvements distributed in a logical and rational manner, based on some objective and measurable criteria? Do improvements negatively affect economically disadvantaged communities? Are improvements with negative consequences necessary for greater state or regional vitality? (Ungemah, 2007, p. 16)

These and other questions could form the basis of an equity review in the project planning stage. Incorporating concerns for equity into planning would also suggest careful examination of the incidence and equitability of alternative funding sources that are under consideration for financing transportation improvements, since congestion pricing can be used primarily as a means of raising revenue as well as to manage congestion. These factors could all be brought together as a kind of equity audit. There is currently no formal definition or guidelines for how this could be conducted, although more specific types of audits have been suggested, such as and Rajé, Grieco, and McQuaid's (2004) displacement parking audit.[3] Developing such a tool would be an important addition to the literature and bring these concerns into the planning realm.

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[1] While it is beyond the scope of this study to go into detail on modeling undertaken to support congestion pricing evaluations, interested readers can find a description of these steps in Small and Verhoef (2007).

[2] At the time this report was written, a congestion pricing proposal for San Francisco was still under preparation, so published modeling results were not available.

[3] A displacement parking audit measures the amount of parking occupied by nonresidents of a neighborhood. The goal would be to determine the impact of nonresidents parking in a neighborhood just outside a cordon and develop policies such that residents still have adequate parking.

Finally, it is important to ensure understanding and meaningful outreach to adversely affected groups (Weinstein and Sciara, 2006; Ungemah, 2007; Mitchell, Namdeo, and Milne, 2005). Ungemah (2007, p. 16) calls this *participation equity* and defines it by asking, "Do disadvantaged communities have a voice in the decision-making process, and is that voice adequately represented relative to the scale of the impact?" While this would not ensure equitable outcomes, it would allow legitimate equity concerns to be raised and facilitate a public discussion of equity.

These concerns about ensuring equitable outcomes in project planning are most relevant in cordon pricing proposals, in which the combined spatial components of the cordon itself and where potentially disadvantaged groups live and work vis-à-vis its location have a large impact on equity. They are probably less important in distance-based pricing proposals, although these are still influenced by regional demographic patterns. They are least important in HOT-lane projects, although there can still be equity implications in such projects: if they do not ensure equitable access (see "Comparing Ways to Implement Congestion Pricing Systems" in Chapter Three), if they toll existing capacity as opposed to adding new capacity, and if they are given higher priority because they raise revenue (Ungemah, 2007, p. 18).

Specific Methods for Addressing Equity

This section discusses three methods to promote equitable outcomes: revenue redistribution, discounts and exemptions, and other tools.

Revenue Redistribution

Revenue redistribution—the use of revenues collected from congestion pricing once the operating expenses are paid—emerged as a main issue in Chapter Three. As discussed in that chapter, economic assessments of equity tend to find that how revenues are used is critical to determining who benefits from and who is harmed by congestion pricing. As a result, using the revenues generated from tolling in an effective way is a critical step toward addressing equity concerns and restoring balance. As with equity assessment, revenue redistribution plays a more important role with cordon and distance-based pricing, both of which tend to induce higher costs and collect substantially more revenues than HOT lanes.

Among existing congestion pricing implementations, the most common way to redistribute revenues is through public spending on specific transportation-related improvements. London, for example, uses most of the revenues on enhanced bus service (Transport for London, 2008), as does I-15 in San Diego (Toups, 2008). The Norwegian toll rings, some of which incorporate congestion pricing, earmark their revenues for a specific package of transportation improvements, including both roadway and transit (Ieromonachou, Potter, and Warren, 2006). While Singapore allocates revenues from road pricing into a general fund rather than earmarking them for transportation (Menon and Kian-Keong, 2004), it invests heavily in transit and affordable housing close to transit. Several proposals for implementing congestion pricing in New York call for using revenues to make transit improvements (New York City Traffic Congestion Mitigation Commission et al., 2008) or reduce transit fares (Komanoff, 2008). The Port Authority of New York and New Jersey, which operates time-of-day tolls on its bridges and tunnels into New York City, earns excess revenue from that program, which is

used to help finance its other expenses, including transit service.[4] Improving transit service is commonly cited as a beneficial use of congestion pricing revenues, as it improves options not to drive.

In particular, in many cases, providing additional bus service may benefit the transportation disadvantaged more than fixed-rail projects, especially when bus service can be added quickly and in more neighborhoods (Rajé, 2003). Transport for London focused on bus service, adding 300 new buses to the roads before congestion charging was introduced and operating a total of 397 million kilometers (247 million miles) of service, the highest level since the 1960s (Transport for London, 2003). Bus ridership increased 18 percent in the first year of congestion charging (Transport for London, 2004). A commission in New York City, reporting on transit funding needs after the cordon pricing proposal was dropped, recommended linking bridge tolls to expanded bus service. The commission argued that bus service was preferred to rail because of rail capacity constraints and the larger service area of buses (Ravitch, 2008).

While improved transit service can be an effective strategy for increasing equitable outcomes, we note two caveats. First, not all transit is created equal, and investments in different modes and neighborhoods may have different impacts. Some have suggested that revenues to improve transit should focus on demand-responsive services or on restructuring transit services (especially those that go through a city center) (Rajé, 2003). These strategies can improve the flexibility of transit services.

Second, transit is not always a viable strategy for addressing equity concerns. The people taking transit may not be the same people who are adversely affected by the congestion charge (Richardson and Bae, 1998). Also, public transportation's ability to mitigate congestion pricing equity concerns is less likely to be salient in the United States, where public transportation accommodates less than 5 percent of trips (Hu and Reuscher, 2004).

A second broad method is to redistribute revenues to individuals rather than spending on public works. This type of redistribution has not been put into practice, but several potential methods have been suggested. One such proposal is called *FAIR lanes* (free and intertwined regular lanes). Under this system, which would be implemented in a HOT-lane context, drivers using the free lanes would receive credits that could be used to pay congestion tolls or transit fares. The concept could also be expanded to the broader highway network (DeCorla-Souza, 2005). DeCorla-Souza (2006) has also proposed a roadway network pricing strategy called *FAST Miles*.[5] In this approach, all motorists would receive a limited supply of credits for peak-period driving; they could pay for more if desired or sell the unused portions to other drivers. A related idea is called *credit-based congestion pricing*. Under this system, all drivers would receive a share of the previous month's revenues; they could continue driving at their usual rates or take the money and spend it on other things (Kockelman and Kalmanje, 2005).

Revenues could also be redistributed in terms of changes in taxation linked to congestion pricing. One proposal seeks to use the revenues to lower gas taxes or other transportation-

[4] The Port Authority noted that, because it operates so many facilities—bridges, tunnels, transit service, airports, and seaports—it is difficult to separate out what proportion of excess revenues from the tolls collected supports transit (Murielo, 2009). However, according to the FY 2009 budget, the Tunnels, Bridges, and Terminals division earned the largest net revenues, $478 million, while the Port Authority Trans-Hudson Corporation (PATH) transit service required the largest subsidy, $336 million. These figures do not include capital expenditures, which are a significant portion of costs (Port Authority of New York and New Jersey, 2008).

[5] Unlike the FAIR in FAIR lanes, FAST is not an acronym.

related taxes; congestion pricing could be implemented as a revenue-neutral policy, but the tax burden would shift to those who drive more frequently during peak periods in congested urban areas (Van Hattum and Zimmerman, 1996). Another study suggests a progressive, refundable, mobility tax credit, under which all households would receive a tax credit based on income, location, number of wage earners, and possibly other criteria (Lewis, 2008). The New York cordon pricing proposal recommends that the state legislature consider changes to tax policy to mitigate the impacts on low-income drivers (New York City Traffic Congestion Mitigation Commission et al., 2008).

A more ambitious, although probably less realistic, suggestion is a mobility unit system, which gives everybody the right to drive or ride transit a certain amount each month. These units could be priced to discourage use at peak times and to favor transit over driving. Drivers wishing to drive more could pay out of pocket (Viegas, 2001).

These revenue-redistribution suggestions—public works and individual redistribution—are not mutually exclusive. Two proposals divided revenues into thirds: transportation investments, direct reimbursement, and tax offsets (Small, 1992); and road improvements, transit improvements, and tax offsets (Goodwin, 1989). Any number of combinations could be proposed, depending on the needs of the community and the extent to which disadvantaged individuals should be compensated.

Redistribution of revenues to transportation improvements is fairly common in existing congestion pricing implementations, but equity analyses of such systems are rare. As noted in Chapter Three, Eliasson and Mattsson (2006) found that using revenues to invest in transit had an overall progressive outcome. While the analysis did consider different locations, some groups were made worse off by use of the revenues for transit investments, presumably because of differing levels of use and access. Replogle (2006) has raised concerns that the financial plans for many HOT-lane projects have dedicated all toll revenues for road capacity expansion, leaving no funding available to ensure operation of transit services in those corridors, reducing the equity of access for people without cars.

The credit and tax systems have not been tried, so it is more difficult to assess their potential impacts. In one model of credit-based congestion pricing, in which all highway driving was priced with real-time changes in tolls, low-income drivers were made better off as a group, but about 5 percent were worse off. Generally, people living at the outer reaches of the areas were worse off than their counterparts closer to the city center (Kockelman, Waller, et al., 2005).

While it is outside the scope of this report to assess the feasibility of implementing individual redistribution mechanisms, depending on the concept, we assume that it would require technological innovation or diffusion, serious attention to privacy issues, legislative approval at the state or federal level (or both), and cooperation between transportation officials at various agencies and across state lines in multistate regions.

As noted in Chapter Three, redistribution based on individual characteristics has the potential to create progressive outcomes when it is correlated with existing income levels. This finding is fairly strong and can be assumed to hold true in many cases. However, it is also possible that most of the current users of the most congested roadways fall into middle- and upper-income groups and that redistribution mechanisms might need to be targeted largely at them to avoid making them worse off. It is more difficult to make a blanket statement about transportation investments, especially where public-transit access varies widely within a region. A fuller analysis of such impacts would include a spatial component of residential pat-

terns, travel patterns, and transit access, and results would likely vary from neighborhood to neighborhood.

Because of this uncertainty, it would be advisable, before designing any revenue-redistribution mechanisms, to assess the impacts of a particular proposed congestion pricing system to determine which groups are disproportionately affected.

Discounts and Exemptions

Discounts, which reduce the congestion charge paid, and exemptions, which exclude certain persons or vehicles from payment, are a common method of addressing equity concerns. All of the cordon systems currently in use incorporate some discounts and exemptions. Discounts and exemptions can be provided in several ways.

Persons. Personal discounts or exemptions can be provided based on demographic characteristics or place of residence. London, for example, exempts disabled persons who apply through its Blue Badge London program. Stockholm exempts residents who live on an island whose only access to the rest of the metropolitan area is through the city center, and London extends 90-percent discounts to charging-zone residents. One proposal in the San Francisco Bay area would have provided lifeline service by exempting very low-income drivers (Van Hattum and Zimmerman, 1996).

Vehicle Type. Here, the discount or exemption is attached to the vehicle, not the driver. Most cities exempt transit and emergency vehicles; others exempt or discount taxis, motorcycles, or low-emission vehicles. Several European cities have recently enacted low-emission zones, in which highly polluting vehicles pay higher charges than low-emission ones. Some of these have congestion pricing components: Milan, for example, charges during weekday daytime hours in five emission classes, with daily charges ranging from €0 to €10 (US$13).[6]

Situational. Discounts or exemptions can be provided in certain situations. For example, Trondheim (Norway) implemented a one-hour rule, under which drivers are charged only once per hour to cross the cordon. This was implemented in response to complaints that drivers dropping off children were charged multiple times (Parkhurst et al., 2006). Some HOT lanes discount or exempt carpools and vanpools, reflecting their origins as HOV lanes.

Of course, discounts and exemptions involve trade-offs; the more exemptions provided, the less effective congestion pricing will likely be, as success depends on having all types of vehicles pay their costs. In London, which has the longest list of discounts and exemptions of any cordon system in place, only 40 percent of vehicle movements within the congestion zone have paid the full congestion charge (R. Evans, 2007). The large number of discounted and exempt vehicles contributed to lower-than-anticipated revenues (Dix, 2004).

There have been very few other studies of how discounts and exemptions have affected those who receive them and whether they have successfully addressed equity concerns. The London study cited in Chapter Three seems to indicate that, under the Blue Badge program, the disabled were not disproportionately affected by the cordon charge.

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[6] Not all low-emission zones can be considered congestion pricing. London's, for example, is in force 24 hours per day, seven days per week (Transport for London, undated). In several German cities (Berlin, Cologne, and Hannover), vehicles that do not meet a minimum emission standard are banned entirely from entering the zone (IEMA, 2008). A fuller discussion of the equity impacts of these zones is outside the scope of this report.

Other Methods for Addressing Equity

A final category serves as something of a catchall, dealing with small operational changes that can negate some potentially adverse impacts. One suggestion involves alleviating the negative impacts of a cordon on neighborhoods just outside it, where residents may fear disproportionate parking impacts (that is, residents of outer neighborhoods may drive in and park just outside the cordon in order to avoid the cordon fees, thus limiting the parking spaces available to residents and businesses). The recommended solution is enforcing parking restrictions to prevent residents of other areas from parking in close-in neighborhoods (Rajé, Grieco, and McQuaid, 2004). The New York proposal included a recommendation for a residential parking-permit program and monitoring of its results (New York City Traffic Congestion Mitigation Commission et al., 2008).

Equity concerns can result from conditions that make it difficult for certain populations to utilize the transportation system. For example, many congestion pricing implementations require the use of a transponder, and the purchaser is often required to have a bank account or a credit card for automatic replenishment. However, this limits the ability of some drivers to participate. This equity issue could be overcome with transponders that can be paid in cash. Singapore, for example, has cash cards that can be removed from the in-vehicle reader and topped up with cash at local stores (Goh, 2002). New York's plan also called for a wide variety of payment mechanisms (New York City Traffic Congestion Mitigation Commission et al., 2008).

Along these lines, programs that require monthly access passes rather than payment for each road use would similarly disadvantage low-income households. While some implementations allow monthly or even annual payments as a convenience (London, for example), having this be the only payment method poses serious equity concerns and should be avoided.

Issues with Promoting Equitable Outcomes

While it is important to consider equity in developing and implementing congestion pricing, it is also important to consider how promoting equitable outcomes can conflict with other goals. Ultimately, as with the definitions of equity, each community must decide how to weigh equity concerns against other legitimate goals.

Trade-Offs Between Equitable Outcomes and Other Goals

The literature notes an important trade-off between efficiency and equitable outcomes. For example, to address environmental-justice concerns, a jurisdiction might provide toll exemptions or discounts to low-emission vehicles. However, such a policy encourages many people to purchase low-emission vehicles to take advantage of this exemption.

In the case of such an emissions-congestion trade-off, benefit-cost analysis can potentially be used to arrive at policies that balance both types of impacts. Benefit-cost principles can be employed because methods exist for valuing changes in both emission levels and congestion.[7]

[7] See, for instance, Parry, Fischer, and Harrington (2004) for an application of benefit-cost principles to the evaluation of changes in congestion and emission externalities stemming from modifications to Corporate Average Fuel Economy (CAFE) standards.

Benefit-cost analysis generally is not applicable, however, when evaluating trade-offs involving equity, since it is virtually impossible to monetize the value of changes in measures of equity.

In another example of a trade-off, the Alameda County Congestion Management Agency commissioned a study (Alameda County Congestion Management Agency, 2005) investigating the merits of HOT-lane pricing on I-680 and I-580 in Northern California. The study incorporated a credit-based proposal that would provide low-income travelers credits that they could redeem for free access to the HOT lane. The study found that, as more users traveled for free in the HOT lanes, HOT-lane speeds decreased. Furthermore, the credit system reduced the revenue generated by the HOT lane, which reduced the financial feasibility of the proposal. The adverse effects on HOT-lane speeds and revenue potential increased with the generosity of the credit system. Polling of local residents indicated that the proposed low-income credit system was not well supported by the public (see Bhatt et al., 2008). In particular, the survey results suggested that concerns about income equity were not a major factor affecting the public acceptance of HOT lanes.

Another equity-efficiency trade-off exists with respect to adopting congestion pricing with targeted discounts and exemptions. Discounts and exemptions may make congestion pricing more equitable, but they also undermine efficiency, since they reduce incentives to discourage low-value trips, promote travel on less congested routes and during less congested times of day, and encourage use of alternative modes, such as public transportation. Policymakers considering various methods to make congestion pricing more equitable must balance the gains in equitable outcomes obtained from offering discounts and exemptions against the potential decrease in efficiency of the transportation system.

Discounts and exemptions may cause other important trade-offs as well. If they are narrowly targeted at those groups that would be disadvantaged, designing such a system may involve high administrative costs per enrolled person (for example, the cost of reviewing documentation to determine a person's income). On the other hand, discounts and exemptions may be applied more broadly, which could reduce the administrative costs but provide discounts and exemptions to those who do not need them, or even invite fraud. In suggesting the personal-mobility tax credit, Lewis (2008, pp. 27–28) notes, "The intent of the model must be to balance the provision of financial assistance to those who require it while avoiding the granting of windfalls to those who would not incur losses from congestion pricing."

Monitoring Equity Concerns

Finally, building equity concerns into congestion pricing requires ongoing monitoring. Conditions should be monitored on a regular basis to ensure that the aspects of a project designed to promote equitable outcomes are still achieving their goals after implementation. Equity outcomes could change over time depending on the geographic distribution of residents and businesses or the relationship of congestion costs to the cost of living.

Equity outcomes could be subject to periodic monitoring in the same way that mitigation measures in some environmental impact reports are monitored. The most recent transportation reauthorization bill called for this type of monitoring: "The Secretary . . . shall . . . establish a program for regular monitoring and reporting on the achievement of performance goals [in demonstration congestion pricing projects], including . . . distribution of costs and benefits" (Pub. L. No. 109-59). This could be a formal program that selects key metrics to measure equity outcomes, measures them through modeling or surveys, reports the results, and makes changes in the equity program to ensure that the metrics continue to be met. For

example, if a program exempted residents making less than $20,000 annually, as the cost of living increases, that dollar amount may have to rise to ensure that all low-income residents are included. London has an extensive annual monitoring program that includes some work on equity measures, such as interviewing Blue Badge holders to assess the impacts of congestion pricing on their well-being (Transport for London, 2008).

However, another consequence of promoting equitable outcomes may be political rather than based on an objective distributional welfare assessment. Incorporating such tools as revenue redistribution (particular to high-visibility projects), discounts and exemptions, or other tools demonstrates a commitment to alleviating negative impacts. Ideally, these tools can both promote equitable outcomes in measurable terms and garner support from the public and elected officials for congestion pricing projects.

CHAPTER FIVE

Conclusion

It is difficult to draw firm conclusions about the equity implications of congestion pricing. It seems safe to say that the debate will continue, partly because of the many possible definitions of equity, partly because there is legitimate disagreement about which groups' needs should be foremost, and partly because other objections to congestion pricing are sometimes made under the pretext of promoting equitable outcomes. This chapter summarizes the conclusions from this report, but, in many cases, they are narrow and cannot be broadly extended to cover every type of congestion pricing or set of possibilities with regard to implementation. Nevertheless, we hope that these conclusions help set some objective markers around what the research shows about equity in congestion pricing.

Defining Equity

We draw two overall conclusions about defining equity. First, equity can be defined in many different and legitimate ways. Researchers must adopt a specific notion of equity in order to perform equity evaluations, but there are multiple notions of equity, including horizontal, vertical, cost-based, and benefit-based, and few studies consider all of these. There is also the problem of which criteria to use to evaluate equity—welfare, transportation access, or environmental justice—as well as the issue of how to categorize people into groups. Because there are multiple definitions, criteria, and groups that can be considered and no study can evaluate all their permutations, even the most complete study is likely to leave one with the uneasy conclusion that not all perspectives may have been evaluated. Finally, to claim that one policy is more or less equitable than another requires a subjective evaluation of the merits of different distributional impacts; what is a superior distributional outcome to one may be viewed differently by others.

This does not imply that it is unimportant to study equity issues associated with congestion pricing. On the contrary, it is very important to study this topic, because congestion pricing will probably play a larger role in U.S. transportation finance in the future for a variety of reasons. Understanding the equity implications is a key aspect of implementing congestion pricing. Rather, we suggest that it is important to define the terms of any such study and to recognize that definitions and criteria can legitimately differ. Groups that advocate for or against congestion pricing should not talk past one another on this topic but make their definitions clear and their assumptions transparent.

Second, equity with regard to congestion pricing is difficult to measure, and few conclusions can be generalized between regions. That is, even if people have similar preferences about

what constitutes an equitable outcome, the contextual elements and assumptions vary widely from place to place. So studies of cordon pricing in two cities, even if they have similar costs and implementation characteristics, may realistically reach different conclusions about which groups are negatively affected or whether congestion pricing is regressive or progressive.

Again, this is not an argument for forgoing the study of equity. Rather, it points to a need to conduct location-specific studies in conjunction with specific proposals. Determinations about whether specific proposals will be equitable should not be based entirely on assumptions or evidence from other areas. Equity assessments need to become more sophisticated so that they can characterize equity impacts in specific locations.

Measuring Equity

With these caveats in mind, we now draw a number of tentative conclusions based on the evidence reviewed for this report. These are based on specific examples cited in Chapter Three (either empirical or modeled), and whether they can be generalized across a wider range of cases depends on the similarities between them. Our answer to the question, "Is congestion pricing equitable?" is, "It depends." The main points in the literature reviewed can be summarized as follows:

- When viewed only as a tax, congestion pricing is mildly regressive, but probably less so than other forms of transportation finance utilized in the United States (particularly the sales tax and motor-fuel tax).
- When congestion pricing revenues are redistributed, the overall effect can be progressive. This may even be the case with a uniform redistribution of revenue to users of tolled facilities, as well as other mechanisms that specifically benefit lower-income groups. Of all the points in this section, we find the broadest agreement that redistribution is key to equitable outcomes.
- Spatial-equity outcomes for cordon pricing systems depend on the patterns of where people live and work, as well as where the cordon is implemented. This finding is also widely supported.
- While current patterns of transportation access are by no means inherently equitable, adding congestion pricing may further burden some people who are already disadvantaged. Even if congestion pricing is deemed vertically equitable in this respect (because lower-income or other disadvantaged groups are, on average, made better off), there may still be problems with horizontal equity (not all members of a group fare equally well).
- While congestion pricing has been found to reduce emissions, the evidence is limited in terms of its effect on equity. This topic deserves further study, as the environmental-justice field suggests that many groups are harmed by existing transportation systems.
- HOT lanes generally create fewer equity concerns among motorists than other types of congestion pricing. While the evidence is strong that HOT-lane users come from higher-income groups, the few studies of HOT lanes have not shown that that lower-income drivers are made worse off. However, the equity impacts of HOT lanes can be affected by

the costs of participation, the patterns of where drivers live and work, and how HOT-lane revenues are used.[1]

Finally, many topics with regard to congestion pricing have received little or no study, and it would be helpful for the research community to explore them. These include the long-term land-use impacts of congestion pricing and the integration of congestion pricing into existing means of transportation finance (as opposed to assuming an either/or scenario between, for example, a gas tax and congestion pricing). We recognize that these are difficult to study because of the lack of long-term data, but, as the track record of congestion pricing lengthens, we hope that such work will be undertaken.

Promoting Equitable Outcomes

As Chapter Four points out, there are a number of ways to make congestion pricing proposals more equitable. We make two overall recommendations that apply to any project. First, equity should be formally incorporated into the planning process, along with such considerations as cost, revenue generation, and other implementation issues. Equity concerns should not be added to the project at a later stage but should be considered during planning and incorporated into modeling for the project, if possible. We support the development of a tool or guidebook for communities to use in this regard.

Second, equity concerns should be monitored in the same way that environmental concerns are, to ensure that project goals are met over time. Whatever mechanisms have been developed to promote equitable outcomes should be assessed on a regular basis to ensure that they are meeting the goals the community has set.

The specific mechanisms to promote equitable outcomes are, like the determinations of equity itself, best identified in conjunction with location-specific proposals. We find little evidence to suggest that certain mechanisms should be promoted in every situation. A key mechanism is revenue redistribution, which is an element of any congestion pricing system that generates revenues in excess of costs. Revenues can be redistributed via investment in public works or through some type of individual mechanism, such as a credit-based system, tax credits, or reduction in other taxes.

The effectiveness of revenue redistribution to promote equitable outcomes depends on the specifics of the implementation and the type of redistribution. For example, a transit project that does not serve the constituencies most negatively affected by congestion pricing would not promote an equitable outcome. While some modeled results show that either type of revenue redistribution can have a positive impact on equitable outcomes, no credit-based or tax-credit systems have been implemented, so there is no evidence on how effective these mechanisms would be.

Two other means of promoting equitable outcomes are (1) discounts and exemptions provided to individuals, vehicles, or in specific situations and (2) other operational changes, such as parking restrictions to prevent nonresidents parking in areas just outside a cordon. Discounts and exemptions are widely used in existing systems, although few formal studies have been done to determine whether they effectively promote equitable outcomes.

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[1] As noted earlier, we are considering only the impacts of creating HOT lanes, not of road building in general.

Finally, we note that, in some circumstances, there are trade-offs between equity and other project goals. Discounts and exemptions can lead to fewer drivers paying congestion charges, which, in turn, weakens those mechanisms' ability to reduce congestion. Credit-based systems on HOT lanes can reduce speeds, thus decreasing the incentive for drivers to pay to use the lanes.

This is not to argue that measures to promote equitable outcomes should not be incorporated—only to point out that it may not be possible to maximize such outcomes while maximizing other goals. Any region considering congestion pricing and wanting to address equity must determine how to define equity, how to measure it, and how strongly to promote it vis-à-vis other goals. Despite a great deal of study and a number of empirical results, the question of whether congestion pricing is equitable must be answered in each region and for each proposal.

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