Road Pricing: Is It Along America's Road to the Future?

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ABSTRACT

In recent years, many cities around the world, including several in the United States, have implemented road pricing schemes as a way to reduce congestion, raise revenue for transportation projects, or a combination of these goals. Road pricing schemes take a variety of forms. The form most commonly found in the United States is high occupancy toll lanes. The federal government is starting to promote road pricing as sound and reliable transportation policy, but road pricing proposals often elicit the concern of many stakeholders, and case studies that would allow decision makers to draw upon previous experiences are limited.

This paper begins by outlining the history of road pricing, including Columbia University economics professor William Vickrey's initial proposals on the concept. It then discusses both the arguments in favor of and against road pricing and established best practices with regards to issues such as financing, revenue uses, and equity concerns to provide recommendations on what should be done to further improve road pricing policy and adequately address the concerns that frequently come up when road pricing is proposed. The paper's ultimate finding is that the established best practices are proving to be sound policy and equity concerns are not as large an issue as many initially fear when a project is proposed. However, additional pilot programs, including a cordon, need to be run before road pricing becomes accepted transportation policy in the United States.

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GLOSSARY

Beneficiary Principle: the idea that taxes should be paid in proportion to the benefits received from public service agencies

Caltrans: California Department of Transportation

Congestion Pricing: Road pricing that varies to discourage travel at peak periods when congestion is high, either on a preset toll schedule or through dynamic pricing where the toll is set in response to actual conditions at a given moment

Cordon (also known as Cordon Tolls): Area in which drivers must pay to drive, such as a central business district. A cordon can also refer to the boundary of the toll area where the toll is usually charged.

Decision makers: Umbrella term referring to people who are responsible for proposing, designing, promoting, and implementing a road pricing system. This term can include planners, government officials, community leaders, commuters, engineers, private entrepreneurs, and other stakeholders.

Electronic Toll Collection (ETC): Cars are equipped with transponders or barcodes that are read at toll collection points, at which point the toll is deducted from the account associated with that particular transponder or barcode

General Purpose Lanes: Toll free lanes on a highway that are open to any vehicle, regardless of occupancy

High Occupancy Toll Lane (HOT Lane): High Occupancy Vehicle lane that allows single occupant vehicles to also use the lane for a fee, the fee is set to ensure that the presence of single occupant vehicles in the lane does not result in congestion

High Occupancy Vehicle (HOV): A vehicle with more than one passenger in addition to the driver. On some roads, a vehicle may need as many as two or three passengers in order to be a high occupancy vehicle.

High Occupancy Vehicle Lane (HOV Lane): Lane in which only vehicles with a certain number of passengers may drive in that lane, the minimum occupancy requirement is indicated by a number following the HOV acronym (i.e. HOV-2 would mean a vehicle must have at least two people in order to use the HOV lane)

Interstate Highway System (IHS): System of highways predominantly funded with federal money and free of tolls to serve major cities and industrial centers

Lexus Lane: Term used to refer to HOT lanes by those who oppose HOT lane facilities on account of equity concerns

London Congestion Charging Scheme (LCCS): Cordon toll in Central London that was initially implemented on February 17, 2003, possibly the most well known road pricing scheme in the world

Mixed Lanes: See "General Purpose Lanes"

Queuing Model: model used in queuing theory to simulate or analyze behavior as a result of needing to form a queue in order to use a facility or to receive a service

Public-Private Partnership: Agreement between public agency and private sector entity that allows for private sector participation in the delivery and financing of transportation projects

Road Pricing: The concept of having drivers paying directly for their individual road use

Single Occupant Vehicle (SOV): A vehicle with only a driver and no passengers or a vehicle that otherwise does not meet the qualifications to be considered a high occupancy vehicle

Value Pricing: See "Congestion Pricing"

William Vickrey: Columbia University economics professor who is considered to be the father of congestion pricing

Sources: Lindsey 2007, box 1; Moon 1994; Victoria Transport Policy Institute. 2008b; Victoria Transport Policy Institute 1992; U.S. Department of Transportation, Federal Highway Administration, Public Private Partnerships; Levinson 2002, 172; Santos 2008.

CHAPTER 1: SETTING AN ITINERARY TO EVALUATE ROAD PRICING IN THE UNITED STATES

Every day in urban areas across the United States, people get in their cars to go to work, school, and to run errands. However, there is a degree of uncertainty in drivers' minds as these seemingly routine trips start. Will a drive to work that typically takes 30 minutes take closer to a full hour, or is traffic so light today that the trip will only take 25 minutes instead? Is it worthwhile to set up a carpool to take advantage of the highway's HOV lane, or might it be simpler to use the HOV lane illegally? Increasing traffic congestion on urban highways means that commuters ask themselves these sorts of questions each day, even if they do not actually realize it.

However, commuters in some parts of the country have been asking themselves a different question in recent years. If time is so valuable, is it worthwhile to pay, possibly as much one dollar per mile driven, to avoid sitting in traffic (Orange County Transportation Authority 2009b; Sullivan 1998)? For many drivers, the answer to this last question is often "yes", and as a result, they are willing to pay to use one of a few high occupancy toll lane, or HOT lane, facilities that exists toady in the United States. This paper examines whether or not having drivers pay for their specific, individual road use, a concept referred to as road pricing, is in fact a feasible transportation policy in the United States based on academic research and actual experiences up until this point, as well as concerns expressed in response to existing and previous road pricing proposals. It also provides recommendations on what should be done in order to make road pricing sound policy that can be more easily embraced by decision makers and travelers in the future. The recommendations include how to decide what type of road pricing scheme to choose depending upon existing traffic conditions and capacity, financing methods for a scheme including how to establish successful public-private partnerships that are beneficial to all parties, how to determine and set the optimal toll rate, how to minimize toll collection costs, how to use toll revenues, how to gain public acceptability for a scheme, and how to address equity concerns.

1.1 Understanding this (Not so) New Phenomenon

HOT lanes are a relatively new innovation in transportation demand management that allow decision makers to use existing transportation infrastructure more efficiently, raise revenue for highway construction and maintenance, promote carpooling and public transportation use, expand highways at little or no cost to the public sector, or a combination of some or all of these objectives (Lindsey 2007, 7-9). Since ancient times, decision makers have struggled to determine the fairest way to raise money to build and maintain roads (Levinson 2002, 17). In 1956, Columbia University economics professor William Vickrey published several papers suggesting that drivers pay directly for their road use, with the price being determined by the amount of demand for that specific road (Victoria Transport Policy Institute 1992). The theory was that the charges would encourage drivers making discretionary trips to make those trips when there was less traffic, change their routes or mode choices, or not drive at all, improving traveling times for everyone (Victoria Transport Policy Institute 1992).

With the advent of reliable electronic toll collection systems in the past few decades, it is now feasible to implement Vickrey's ideas if decision makers wish to do so. However, travelers want to know how the toll collection systems are going to work, how public authorities will use the revenue raised by the tolls, and how road pricing will benefit them. Additionally, many are concerned that those who cannot afford to pay or avoid the tolls on a daily basis will face financial difficulties, high levels of congestion, or be unable to drive between home, work, and other important destinations (Ungemah 2007, 14). These types of concerns have always existed, but decision makers must be able to mitigate these concerns to be able to implement road pricing of any kind successfully.

1.2 Definitions and Other Important Terminology

HOT lanes are highway lanes that drivers must pay to access if they have less than a certain number of passengers in the car. They are a form of road pricing, or making drivers pay directly for their road use as opposed to using indirect charging methods such as gas taxes. Other forms of road pricing include tollbooths and cordons. All of these tolling options, as well as other important terms for a discussion of road pricing, such as single occupant vehicle (SOV) and high occupancy vehicle (HOV), are identified and defined in the glossary.

1.3 Mapping Out Our Itinerary

Although the U.S. Federal Highway Administration encourages the construction of HOT lanes, studying road pricing has been difficult until fairly recently because there were very few successful implementations of road pricing schemes anywhere in the world (U.S. Department of Transportation 2008, I-1). A list of some existing schemes is provided in table 1.1. Several questions need to be asked to determine whether decision makers have enough experience with road pricing to implement it on a wide scale in the United States,. Do decision makers now have enough successful (or failed) road pricing implementation attempts to be able to determine whether newer strategies, such as HOT lanes, can in fact be successful? Regardless of the answer to this first question, what additional steps should be taken, if any, before HOT lanes and road pricing become accepted transportation policy in the United States? These questions and the answers to them often apply not only to HOT lanes but also to other forms of road pricing, such as express toll lanes and cordons. However, since most road pricing scheme proposals in the United States are for the implementation of HOT lanes, the primary focus of this paper is HOT lanes.

This paper addresses these questions by examining the history of road financing, maintenance, and tolling from the colonial era up until 1956 (Chapter 2), which is when Vickrey began to write about his theories (Chapter 3). This history focuses on who has been responsible for financing road construction and maintenance, and how these burdens have shifted from group to group for different reasons over time. The introduction of Vickrey's theories in 1956 is a watershed moment in this history, and his theories have influenced all road pricing discussions since that time. There will then be a discussion of why HOT lanes are an attractive road pricing strategy (Chapter 4). The discussion begins by analyzing the results of the 1964 Smead Report and responses to it in order to establish a groundwork for the rest of the discussion, which continues topically. The second part of this discussion explains why the costs of congestion, the underutilization of HOV lanes, and the advent of public-private partnerships have made HOT lanes and other road pricing proposals so attractive. This is followed by identifying the key components to any successful road pricing implementation, including picking the proper road pricing option, ways to finance a project, potential toll revenue uses, how to involve the public and how to counter equity concerns (Chapter 5). These two chapters include established best practices, such as using electronic toll collection to reduce the cost of collecting the toll, identifying and involving stakeholders throughout the entire planning process, designing a road pricing scheme that benefits non-drivers and those with lower incomes, and ensuring that an alternate, toll-free route remains available to travelers who are unable or unwilling to pay the toll. Chapter 5 also incorporates case studies from around the world, including Orange County, CA, San Diego, Minneapolis, Toronto, and London. Finally, the paper concludes by recommending that additional road pricing experiments be carried out here in North America before road pricing is embraced as successful and sound transportation policy in the United States (Chapter 6). Recommendations include developing pilots for credit based congestion pricing, a cordon toll similar to the London Congestion Charging Scheme, and additional pilots to verify the results found in experimentation that has been completed to date, especially with regard to findings that equity concerns pertaining to road pricing are often unfounded.

Table 1.1: Examples of Road Pricing Schemes

Road/ Project Name	Location	Implementation Date	Description
California State Route 91	Orange County, CA	1995	HOT lane facility constructed in highway median, originally public-private partnership that reverted to public sector control in 2003 following dispute between partners, HOVs pay discounted toll
E-ZPass	Northeast United States	1993	Although not the first electronic toll collection system in the United States, it is one of the most widely used, currently in use in 13 states
Highway 407	Ontario, Canada	1997	World's first fully electronic toll road, leased to private operator for 99 years starting in 1999
Interstate 15	San Diego, CA	1996	HOT lane facility constructed in highway median, HOVs pay no toll
Interstate 394	Minneapolis, MN	2005	HOT lane facility constructed in existing highway median, notable for significant public involvement in planning process
Interstate 495	Fairfax County, VA	Under Construction	HOT lane facility under construction in existing highway median through public-private partnership
Interstate 95	Miami, FL	2008	HOV lane converted to HOT lane
Interstate 95/395	Northern Virginia	Under Development	Proposed conversion and expansion of existing HOV facility to HOT facility through public-private partnership
London Congestion Charging Scheme	London, England	2003	Cordon toll in Central London used to finance public transportation projects
Singapore Area Licensing Scheme	Singapore	1975-1998	Considered to be one of the first successful road pricing schemes anywhere in the world, required purchase of paper license prior to driving in central Singapore, phased out in 1998 in favor of Electronic Road Pricing
Singapore Electronic Road Pricing	Singapore	1998	Replaced Area Licensing Scheme and made road pricing in Singapore a fully electronic system

CHAPTER 2: HISTORY OF AMERICAN ROAD CONSTRUCTION, ROAD FINANCING, AND TOLLING PRIOR TO 1956

The concept of road pricing is not a new phenomenon; debates over whether or not exemptions or discounts should be provided to certain drivers and equity impacts, among other topics, have been ongoing for many years. Although the actual methods of road pricing have varied from place to place over time, many authors agree that the goal of all these revenue raising efforts has been to provide maximum benefits to the local residents using the road while minimizing the amount of money and inconvenience to these same residents, not to control congestion (Levinson 1998, 14). Yet it is still important to know the history of road financing and understand who has typically paid for their road use prior to 1956, which is when serious discussion of charging drivers for the congestion they cause began.

2.1 Road Financing in the Northeast United States Prior to 1900

2.1.1 Prior to the Turnpike Era

The first tolled travel facility in the United States was a bridge in Newbury, Massachusetts, where a toll was charged to raise funds for maintenance starting in 1656 (Levinson 2002, 23). Bridges have been tolled throughout the country ever since in order to raise money to finance their construction or maintenance, but the history of tolling larger sections of transportation infrastructure is far more complex.

American road maintenance was initially the responsibility of the local labor force, and some states required that all able bodied males were required to perform up to thirty days of labor per year if requested to do so by the town highway commissioner (Levinson 1998, 17). However, laborers found it easier to pay the penalties associated with delinquency than to do the actual work, and those who did the work did not put in a full effort. Yet these types of systems remained in place until the early part of the twentieth century in some parts of the United States (Levinson 1998, 17).

2.1.2 The American Turnpike Era

The turnpike era in the northeast United States began in the late 1700s (Levinson 2002, 23). The decision to construct tolled turnpikes was made in response to rural residents who felt that they were funding the maintenance of roads used primarily by urban dwellers making intercity travel (Levinson 2002, 23). Virginia and Maryland were the first states to allow tolls to be charged on public, tax funded roads in 1785 and 1787, respectively (U.S. Department of Transportation 1976, 8). However, the first "significant" turnpike in the United States was chartered in 1792 and opened in 1794, connecting Philadelphia to Lancaster in Pennsylvania (U.S. Department of Transportation 1976, 8). Aside from in Pennsylvania, few turnpikes in the United States received funding from the state governments, and James Monroe vetoed legislation that would have instituted tolls along the federally funded National Road, saying that the tolls were unconstitutional (Levinson 2002, 24). The federal government would avoid funding toll roads until the end of the twentieth century.

The construction of canals and railroads, such as the Erie Canal, ultimately led to the decline of the turnpikes. As canal and railroad networks expanded, unprofitable sections of turnpike were abandoned and often became public, free roads (Levinson 1998, 25).

2.1.3 Lessons Learned from American Road Financing Prior to 1900

Much of the criticism that American turnpikes received prior to 1900 was similar to the criticism that road pricing faces today. Many travelers viewed roads as a public good that should provide free access to all users, and travelers who only used the turnpikes for short distances were especially upset by the idea that they now had to pay for road access that had previously been free (Levinson 2002, 27). A variety of solutions were devised to solve this sort of problem, but the solutions came with consequences. In New York, tolls were placed ten miles apart, which facilitated local free riders, and a Massachusetts law made anyone traveling to or from a gristmill or church, people on military duty, and those traveling on "command and ordinary business within the tollgated town" exempt from paying the toll (Rae 1971, 17-18). These sorts of policies and laws still did not satisfy everyone however, and "shunpikes" were created so that travelers could illegally bypass the section of road with a tollgate and avoid paying the tolls (Levinson 2002, 25). The facilitation of free riders and the construction of shunpikes greatly affected turnpikes' ability to turn profits (Levinson 2002, 25). Other travelers resented turnpike operators and feared that the operators would set toll rates with the primary purpose being to get rich at the expense of travelers, a concern that still exists today with public-private partnerships (Levinson 2002, 27).

2.2 Road Financing in California Prior to 1900

The history of road financing in California differs from that of the northeast part of the United States in several ways, and it is important to note these differences since California continues to be a frequent trendsetter in terms of road financing and other transportation initiatives. California turnpike construction started during the Gold Rush, over fifty years after the turnpike era began in the northeast United States (Levinson

1998, 25). California turnpike laws were often based off the laws of the northeastern states, but California turnpikes were generally set up as businesses meant to make a profit, whereas northeastern roads were seen as "community enterprise[s] without a significant profit motive" (Levinson 1998, 25; Klein and Yin 1996, 678).

2.3 American Road Financing from 1900 to 1956

The roads and turnpikes described up until this point were designed for pedestrians and carriages drawn by animals. However, the invention of rubber tired vehicles such as bicycles and subsequently automobiles required that new types of roads be constructed that could handle these types of vehicles. Although Congress expressed interest in building a national highway system as early as 1916 and funded the construction of a national highway system prior to the United States Interstate Highway System (IHS), it was not until the predominately federally funded and toll free IHS was completed that the needs of rubber tired vehicles were truly fulfilled (Levinson 1998, 26).

2.3.1 Before the Interstate Highway System

There were a few attempts at having private companies build limited access highways in the twentieth century, including William Vanderbilt's Long Island Motor Parkway and Robert Moses's Northern State Parkway, also on Long Island (Levinson 1998, 26). However, funding for paved, limited access roads in the United States would end up coming from the state and federal government in most cases. Between 1919 and 1929, every state began to charge a gas tax in order to raise money to fund road construction and maintenance (Moon 1994, 4). For most of the twentieth century, gas tax money could not be used for any purpose aside from road construction or maintenance (Levinson 1998, 27). While northeast states did create turnpike authorities to construct paved, intercity roads prior to the construction of the IHS, many believed that intercity highways should be toll free, including the Bureau of Public Roads, which published a report in 1939 called "Toll Roads and Free Roads" claiming that toll revenues would not cover even half of the annual costs to operate a national highway network (Rae 1971, 171). While the Bureau of Public Roads' predictions were not realized, the majority of the United States' twentieth century freeways were built as toll free facilities. The first large scale, twentieth century freeway project to be completed, the Pennsylvania Turnpike, opened in 1940 without having received any federal funding for its construction (Levinson 1998, 28). Other bridges and tunnels, including the San Francisco-Oakland Bay Bridge and the George Washington Bridge between New York and New Jersey were constructed as toll facilities prior to the construction of the IHS, and were later grandfathered into the IHS (Levinson 1998, 27).

2.3.2 The United States Builds a National Road Network

During World War II, the need for a national highway network, to be used for both general transportation and defense purposes, similar to Germany's *autobahnen*, became apparent. Congress first showed interest in building a national highway system in 1916 when it passed the Federal-Aid Road Act of 1916, and the idea was discussed by both government leaders and industry officials during the next twenty-eight years, but no significant progress was made until the Federal Aid Highway Act of 1944 was passed (Moon 1994, 7). This act authorized the creation of the IHS "to connect by routes, as direct as practical, the principal metropolitan areas, cities, and industrial centers to serve the national defense, and to connect at suitable border points with routes of continental importance," but no funds were actually appropriated for construction (Moon 1994, 7).

Funds were not appropriated for the IHS until President Dwight Eisenhower signed the dual Federal-Aid Highway Act of 1956 and Highway Revenue Act of 1956 into law on June 29 of that year (Moon 1994, 7). The legislation included design criteria and standards for all segments of the IHS, as well as the creation of the Highway Trust Fund to be funded by a federal gas tax that would provide 90 percent of the funds needed to construct the IHS; the remaining 10 percent of construction costs would be funded by the individual states (Moon 1994, 10). Tolls would not be collected to raise money for construction. The primary factors behind this decision were that the American Automobile Association and trucking interests were opposed to toll roads, and as previously mentioned, it was believed that toll revenues would not raise a sufficient amount of money to build the entire IHS (Gómez-Ibáñez and Meyer 1993, 167-168). Aside from preexisting toll facilities, such as the Pennsylvania Turnpike, that were grandfathered into the IHS, the highway network was to be toll free.

Figure 2.1: Interstate Highway System (IHS) Timeline

1916: Congress shows first signs of interest in building a national highway system with passage of Federal-Aid Road Act of 1916
1939: Bureau of Public Roads predicts that toll revenues could not cover even half of annual operating costs for national highway network
World War II: Need for national highway network becomes more apparent
1944: Federal Aid Highway Act of 1944 authorizes creation of IHS but provides no funds for construction
June 29, 1956: Federal-Aid Highway Act of 1956 and Highway Revenue Act of 1956 signed by President Eisenhower, establishing IHS design criteria, and creation of Highway Trust Fund

Source: Data adapted from Moon 1994.

2.4 Conclusion

The decision to construct the IHS was a momentous event in the United States' transportation history. At about the same time, however, another momentous event occurred that, until recently, gained little attention outside the world of academia. This event will be discussed in the next chapter.

CHAPTER 3: WILLIAM VICKREY'S CONGESTION PRICING THEORY

3.1 Who Was William Vickrey

Columbia University economics professor William Vickrey, widely considered the father of congestion pricing, was born in Victoria, British Columbia, Canada. After receiving his BS in mathematics from Yale University in 1935, Vickrey attended Columbia University where he studied economics and received an MA degree in 1937 (Victoria Transport Policy Institute 1992). Vickrey's first studies of efficient pricing for public utilities took place in 1939 and 1940 when he looked at the pricing of electric power for The Twentieth Century Fund (Victoria Transport Policy Institute 1992). However, Vickrey would spend the majority of his professional career working at Columbia University, where he would write his initial theories on why congestion pricing should be adopted (Victoria Transport Policy Institute 1992).

3.2 Extending Efficient Pricing Principles to Transportation

Vickrey was not the first person to suggest that traffic congestion or travel patterns could be controlled through pricing. In his 1920 work *The Economics of Welfare*, British economist Arthur Pigou suggested that negative externalities should be offset by a tax paid by the person who creates the negative externality, and that a positive externality should be rewarded with a subsidy (Darity 2008). However, Vickrey is considered by many to be the first person to attempt applying this type of theory to a realistic situation (Arnott 1994, 271).

3.2.1 Vickrey's Initial Proposal: Efficient Pricing on the New York City Subway

3.2.1.1 Aspects of the Fare Collection Problem

In 1951, Vickrey was commissioned by the City of New York to come up with proposals for how to change the New York City subway's fare structure to reduce the transit deficit in the city's budget (Vickrey 1994a, 277). Vickrey's 1955 report to the city, *A Proposal for Revising New York's Subway Fare Structure*, marked the first time that demand management and the costs of fare collection were seriously considered in determining the rates to be charged for public transportation use. Many of the potential problems that Vickrey highlighted in changing the subway fares are also potential problems for road pricing schemes for automobiles.

Vickrey begins his proposal by identifying six "aspects of the [fare collection] problem" that must be accounted for when setting subway fare rates; these can be seen in table 3.1 (Vickrey 1994a, 277). The political problem is often the most challenging aspect of the problem to satisfy, and doing so is critical to the success of any pricing proposal. Generally, pricing schemes that are considered to be reasonable and equitable face little public opposition, which significantly eases their implementation. However, Vickrey focuses on the utilization aspect the most in *A Proposal for Revising New York's Subway Fare Structure*. This aspect examines how the fare structure affects the system's overall efficiency, with the goal being to realize efficient utilization (Vickrey 1994a, 278).

An economist's definition of efficient utilization means that "the value of the benefits produced by all of the services provided by a utility shall exceed the costs of rendering that service by as large a margin as possible" (Vickrey 1994, 278a). Vickrey

Table 3.1: William Vickrey's Aspects of the Fare Collection Problem

Aspect	Description/Example
Revenues	If the city were to raise or lower the subway fare, the subway's revenues would change and the city would need to adjust its tax rates to ensure that its finances remain in order
Fare Collection Costs	If the cost of collecting fares is too high, potential revenues for the system will be limited
Distribution	Revenues must be distributed fairly across the city population
Political Problem	Fare proposals must be deemed reasonable and equitable to both politicians and passengers
Ecology/Geography/ Sociology	Consideration of effects of a fare structure on the city's geographical pattern of development, concentration of businesses, and residents' general living and working patterns
Utilization	How a fare structure impacts the system's overall efficiency

Source: Data adapted from Vickrey 1994a, 277-278.

says that to achieve an efficient utilization of the subway, the fare must fully reflect the cost of carrying passengers "at all times and between all points" (Vickrey 1994a, 279). For example, if fares were raised during rush hour, people might deem the subway service to be too crowded and too uncomfortable to justify paying the higher fare, but those who continue to pay the higher fare would receive a higher level of service because the train would not be as crowded as it was before. Conversely, if seats are plentiful during the off-peak hours along routes where passengers want more service, fares should be lowered before new service is introduced because the current service is underutilized.

3.2.1.2 Pricing the Subway to Meet Demand

Vickrey then examines the structure of subway costs by looking at the number of train miles and car miles operated per year, the number of subway cars in use at the peak of rush hour service, the number of passengers carried each year, the peak number of passengers carried per hour, and the system layout, while also factoring in other variables such as the cost of electricity to power the trains and the wages of the train crews

(Vickrey 1994a, 280). During off-peak periods, adjustments in service are easy to make since there are many options for how the city could expand or reduce service as needed. For example, in order to maintain the desired level of service, trains could be lengthened or shortened to meet ridership demand (Vickrey 1994a, 281). During rush hour, making adjustments to meet demand is more difficult if trains are already at their maximum length or if a track is being used at its maximum capacity. However, the city can create incentives to encourage off-peak ridership by giving passengers who do not use the subway during rush hour a discounted fare (Vickrey 1994b, 308). Such a decision also has the potential for the city to gain additional revenue as a result of people taking the subway to make discretionary trips they might have not made had the fare not been discounted. Rush hour ridership may decrease slightly as people seek to avoid the higher fare (Vickrey 1994a, 285). At the same time however, other riders may be willing to pay a higher fare to ride a train that is less crowded, offsetting any loss in revenue as a result of lower ridership (Vickrey 1994a, 285). These same basic considerations are made when the potential of HOT lanes is discussed.

3.2.1.3 Implementation Hurdles

While the economic argument for adopting this type of fare system is logical, implementing it in the 1950s would have had its fair share of difficulties due to the lack of technology available at the time, and concerns that such a system would result in the costs of collecting the fares becoming prohibitively high. In order to charge variable fares, Vickrey proposed using a turnstile that would give each passenger a metal check upon paying an entrance fee. When the passenger reached his or her destination, the check would be inserted into an exit turnstile that would give the passenger any refund he or she was entitled to based on the distance traveled and the time at which the trip started (Vickrey 1994a, 289; Vickrey 19994b, 308). However, Vickrey himself acknowledged that “no working model of such a turnstile has been produced” (Vickrey 1994a, 289). Additionally, prior to the start of Vickrey’s study, the subway earned $160 million in revenues each year but spent $12 million on fare collection (Vickrey 1994a, 291). Therefore, Vickrey made some additional suggestions as to how his fare proposals could be implemented without losing as much of the fare revenue to collection costs.

3.2.1.4 Acknowledgement of Negative Impacts

Although Vickrey admitted that an increase in transit fares “is about as regressive a tax as can well be imagined,” he did little analysis on how his proposals might actually affect low-income riders (Vickrey 1994a, 302). However, he did hypothesize on how the lower classes might benefit from his proposals, saying that low-income workers were more likely to work odd hours and live closer to the city center, meaning they would be less likely to have to pay the highest fares (Vickrey 1994a, 303). Vickrey also acknowledged that his proposals could potentially alter urban development patterns and force businesses to move from the city center as residents and workers adjusted their lives to minimize the charges they would incur on a daily basis (Vickrey 1994a, 305).

Vickrey’s proposals were made solely on their economic merits with no acknowledgement of the “popular notions of what is equitable or proper” (Vickrey 1994a, 304). In fact, Vickrey believed that giving in to such demands would reduce the effectiveness of his proposals (Victoria Transport Policy Institute 1992). However, it should be noted that placating equity concerns and receiving acceptance of the proposal from the public are key to the success of nearly every pricing proposal, and Vickrey was right to note that his proposals were not necessarily viable solely on their economic merits. A certain balance between economic rules and understanding the needs of people is required in order to implement successful road pricing schemes.

3.2.2 Vickrey's Theories Applied to Roads

Up until this point, Vickrey's demand pricing proposals only pertained to subways and commuter rail systems. However, it was not long before he began to apply some of his ideas about subway fares and demand management to roadways as well. Vickrey wrote that most drivers believe that their highway and license taxes fully pay for their roadway use, yet this assumption is not correct (Vickrey 1994b, 309). Like on the subway, rush hour road use is very under priced relative to the amount of demand during that time of day (Vickrey 1994b, 310). Additionally, the construction of expensive freeways could be avoided if tolls were charged on congested routes, directing traffic to less congested routes with lower tolls or no tolls at all (Vickrey 1994b, 310).

3.2.2.1 Benefits of Road Pricing

Vickrey predicted that "charging for street use could have a far-reaching impact" on many aspects of urban transportation (Vickrey 1994b, 314). Road pricing would force travelers to pick their route and decide if the trip is truly necessary based on the actual cost of the trip and not on their own personal whims (Vickrey 1994b, 314). Public transportation could be expanded in response to increased need as former drivers choose to take less expensive subway or bus trips instead of driving (Vickrey 1994b, 315). People would work and partake in leisure activities as close to home as possible to avoid the costs that would be associated with lengthy, expensive trips (Vickrey 1994b, 315). To promote bus use, buses could be provided with dedicated lanes so that they would not be caught up in the same traffic as personal vehicles (Vickrey 1994b, 315). However, Vickrey pointed out that existing bus service using its own dedicated lane would result in that dedicated lane being very underutilized, a problem that continues to exist today with dedicated bus lanes and also HOV lanes (Vickrey 1994b, 315). The last benefit of road pricing would be that through traffic could be routed around a congested city center via ring roads with a low toll or no toll that would shorten the overall travel time, leaving the center city roads to be used by those who actually need to use them (Vickrey 1994b, 316). In this situation, the prices would need to be set such that the through traffic had a strong incentive avoid driving through the city center.

3.2.2.2 Implementation

Even in the 1950s, road pricing created the image "of a clutter of toll booths, an army of toll collectors, and traffic endlessly tangled up in queues" (Vickrey 1994b, 312). While Vickrey had ideas on how to ensure that toll collection would be rapid and not contribute to the congestion that he looked to reduce, his proposed toll collection methods were not technologically feasible at that time, and it is only with the recent advent of the necessary technology to implement reliable, large scale road pricing schemes that is allowing governments around the world to seriously consider implementing road pricing now.

Vickrey's preferred choice for toll collection was to install all cars with an electronic identifier that could be read by roadside equipment. The data collected by the roadside equipment would be collected and bills would be mailed to the drivers in the same way that phone bills were mailed to individual residences (Vickrey 1994b, 312). Variable message signs would display the current toll rate to drivers before they crossed the cordon where the toll would be assessed so that they could choose another route if they wanted to do so (Vickrey 1994b, 312). Other options included having a meter based system under which drivers were responsible for setting a meter installed in their car to a specific rate depending upon how much traffic was in the city, or meters that would charge the appropriate rate based on electronic signals sent out from wires embedded in the road (Vickrey 1994b, 313). Under the latter system the driver would not be responsible for selecting the appropriate rate, reducing the ease with which the system could be cheated (Vickrey 1994b, 313).

Vickrey also had ideas on how to accommodate cars from out of the city that may not have the electronic identifier or meter required to pay the tolls. Vickrey suggested that such vehicles could simply be allowed to use the roads for free "in a spirit of hospitality", or that temporary meters or electronic identifiers could be made for sale at designated entrances to the tolled area (Vickrey 1994b, 314). Vickrey also proposed using cameras to assist in enforcement by having them photograph cars that set off a nearby trigger indicating that they had no functioning electronic identifier or meter (Vickrey 1994b, 314). While many of these ideas were not possible when proposed in the 1950s, nearly every road pricing scheme today uses electronic transponders to identify each vehicle and assess the proper toll, and cameras are a key enforcement tool.

3.3 Vickrey's Principles of Efficient Congestion Pricing

Over the course of his career, Vickrey published several books and many papers. While not all of these pertained to applying efficient pricing principles to transportation, over time, Vickrey developed a set of principles on how efficient congestion pricing should be implemented. Even following years of debate and more recently, actual implementation of these ideas, many academics, public officials, and planners stand by these principles, and I have also adopted some of them in my own set of suggested best practices. Table 3.2 shows specific schemes where these principles have been adopted (or in some cases, rejected).

3.3.1 Establishing the Schedule of Charges

The most important principle in implementing efficient pricing to a transportation system is to ensure that the charges assessed reflect the marginal social cost of each trip and its impact on other travelers (Vickrey 1994a, 278; Victoria Transport Policy Institute 1992). While Vickrey says a slight surcharge can be added to the toll in order for the local government to make some revenue, significant markup from the socially optimal price will render the pricing scheme inefficient, as will setting the toll at any price lower than the marginal social cost (Victoria Transport Policy Institute 1992). In calculating the marginal social cost, it is necessary to remember that the effects of an additional car in a congested area may not dissipate for hours, and charges should reflect the impact that a single car can have on all other cars entering a congested area until that congested traffic is free flowing again (Vickrey 1994b, 317; Victoria Transport Policy Institute 1992).

Another principle to heed when implementing efficient pricing is that charges should vary smoothly over time (Vickrey 1994a, 279). If there is a significant difference in the price from hour to hour, people will try to make their journey just before or after the most expensive charge is levied creating a new rush hour and congestion at a time when there was previously none. Additionally, a preset schedule of toll rates will result in less than optimal prices following an accident or sporting event and during inclement weather; rates should always be reflective of the actual conditions at a given moment and not predictions (Victoria Transport Policy Institute 1992). Finally, Vickrey also said that tolls should not be charged simply for passing a certain point along the boundary of a congested area, but a method should be adopted such that one is charged based on the specific route a driver takes through the tolled zone (Victoria Transport Policy Institute 1992; Vickrey 1994b, 316-317). This provides an incentive for traffic to be routed to the least congested routes, but it can be controversial since it violates the principle of maintaining alternate, toll free routes discussed in section 5.3.5.3.

3.3.2 No Exceptions to the Rules

Vickrey believed that applying efficient pricing to transportation was a pure economics game under which there should be no discounts or exceptions from paying the tolls. Vickrey predicted that commercial vehicles, taxis, doctors, policemen, firemen, members of the press, elected officials, mailmen, and diplomats all might try making a case for receiving an exemption from paying the tolls, but that none of these people nor anyone else had a valid reason for needing an exemption (Victoria Transport Policy Institute 1992; Vickrey 1968, 117). Exceptions invalidate market pricing principles, and it is more equitable, not to mention efficient, in Vickrey's view to charge everyone than to provide exceptions for only some (Victoria Transport Policy Institute 1992). Vickrey suggested that taxi drivers pass the congestion charge on to their passengers so that the taxi drivers would not be losing all their fare revenue to congestion tolls (Victoria Transport Policy Institute 1992).

Vickrey also believed that "political interference and bureaucratic bungling [would] spoil the [economics] game" that road pricing forced travelers to play (Victoria

Transport Policy Institute 1992). Vickrey acknowledged that implementing efficient pricing would "go counter to popular notions of what is equitable or proper" and rarely be in the political interest of elected decision makers because people would feel as if they were paying for something that had previously been free (although he would maintain that it was grossly under priced but not free) (Vickrey 1994a, 304). However, Vickrey also believed that the potential benefits of efficient pricing outweighed these potential concerns, and he hoped that government officials would realize this (Vickrey 1994a, 304; Victoria Transport Policy Institute 1992). Vickrey predicted that those who would be adversely affected by this would be vocal in their opposition, but that with "earnest education" initiatives and public outreach, this opposition could be countered, and ultimately, widespread road pricing would be accepted by society at large (Victoria Transport Policy Institute 1992). Recent case studies, such as the one in section 5.3.4.4, show how this approach can be successful.

3.4 The Initial Impact of Vickrey's Theories

Vickrey's proposals were many years ahead of their time, both in terms of the lack of technology with which they could be implemented in the 1950s and also in terms of public acceptability at the time. However, it is remarkable to think about how many aspects of Vickrey's theories have been regarded by other academics and planners as good ideas and have ultimately been implemented. This is not to say that Vickrey had everything with regards to road pricing figured out in the 1950s or that every one of Vickrey's ideas should be regarded as a best practice, because as case studies show, neither statement is true. Many have doubted and challenged some of Vickrey's ideas and principles over the years, as we will see.

Table 3.2: Vickrey's Principles of Efficient Congestion Pricing

Principle	Vickrey's Rationale	Accepted	Example
Use Variable Pricing	Preset pricing schedules cannot account for special conditions such as major accidents, inclement weather, or the conclusion of sporting events	Somewhat	Interstate 15, San Diego, CA
Charges Should Vary Smoothly Over Time	Significant price changes will result in drivers attempting to avoid the peak charges, creating congestion at times when there had previously been none	Widely	California State Route 91, Orange County, CA: Interstate 15, San Diego, CA
Charge For Specific Routes	Charging higher rates on the most congested routes would provide a greater incentive to drivers to consider using less congested routes, improving traffic flow throughout an entire region	Somewhat	Seattle VMT Pilot Program
No Exemptions or Discounts	Efficient pricing of transportation is a pure economics game under which no person has a valid reason for needing an exemption or discount from the toll	No	London Congestion Charging Scheme (does provide discounts and exemptions to some users)
Use Public Education to Counter Rationale	Education initiatives would teach traveling public about the benefits of road pricing, allowing politicians to implement tolls that would otherwise be resisted	Widely	Interstate 394, Minneapolis, MN

Source: Data adapted from Victoria Transport Policy Institute 1992; Vickrey 1994a; Vickrey 1994b; Vickrey 1968.

CHAPTER 4: THE ARGUMENTS FOR CONGESTION PRICING

Road pricing proposals have been made more frequently in recent years as the need for money to expand and rebuild existing highway infrastructure has increased in conjunction with technology advances that make the implementation of Vickrey's proposals more feasible than ever before. However, for a variety of reasons, there have always been many people who are skeptical of Vickrey's theories and road pricing proposals in general. Until recently, most discussions pertaining to the merits and disadvantages of implementing road pricing have taken place solely in the academic realm, but as road pricing programs have been constructed in the United States and elsewhere, the number of case studies available on the subject has increased significantly. Through the analysis of both academic work and case studies, the next two chapters will address past and current arguments and theories, both for and against road pricing, in an attempt to develop a set of best practices to be used in the development of new road pricing proposals.

4.1 Early Academic Discussions of Road Pricing

Road pricing certainly has its proponents, but those who are skeptical of Vickrey's proposals have made their concerns known over time, starting shortly after Vickrey wrote *A Proposal for Revising New York's Subway Fare Structure* and *Pricing in Urban and Suburban Transportation*.

4.1.1 The Smead Report

In 1962, the British Ministry of Transport set up a panel chaired by R. J. Smead "to study and report on the technical feasibility for improving the pricing system relating to the use of roads," (United Kingdom 1964, 1). The panel's report is referred to as the Smead Report. The Smead Report and the responses to it are useful in seeing how the various arguments taken by both proponents and opponents of different types of road pricing were initially shaped, and how some of Vickrey's theories were incorporated into the first discussions about how to implement a variable road pricing scheme. Many of the ideas and suggestions contained within the Smead Report have remained relevant up until today.

The Smead Report lists nine "important requirements" of a road pricing scheme that have been maintained nearly universally as best practices or ideal goals since the report was published in 1964. At that time, Britain charged for road use primarily through fuel taxes, annual licenses, and purchase taxes (United Kingdom 1964, 8). However, the panel concluded that these taxes did not correspond to an individual's actual road use and that other methods of road pricing should be explored to raise money to build and repair roads, and also to decrease congestion. The panel said that any new system had several "operational requirements" in order for the new system to be effective that are listed in table 4.1 (United Kingdom 1964, 7). A variety of potential collection methods were also included in the report, including a system where cars would have electronic identifiers scanned as certain locations were passed, much like Vickrey's own proposal (United Kingdom 1964, 18). The panel believed that this type of road pricing scheme would decrease and reduce the cost of congestion, resulting in time savings, decreased fuel costs, and increased productivity in public transportation services (United Kingdom 1964, 36). It was proposed that revenues generated from the scheme could be distributed to local authorities for road maintenance and construction, to subsidize public transportation, or to reduce existing motorist taxes (United Kingdom 1964, 39). However, the panel was not required to consider the social or political implications of its work and proposals, nor did it opt to attempt predicting people's actions in response to the implementation of road pricing (United Kingdom 1964, 1). As a result of not being required to examine these types of implications and the lack of technology with which to test possible schemes, the Smead Report offered no concrete recommendations as to whether or not the type of road pricing scheme it proposed actually be implemented (United Kingdom 1964, 40-41).

Table 4.1: Smead Report: Operational Requirements of a Road Pricing System

1. Charges should be closely related to the amount that each road is used, this can be measured in terms of either time or distance
2. It should be possible to vary prices for different roads or areas based on time of day, week, or year, and also by vehicle class
3. Prices should be made known to drivers before they are charged
4. It should be possible to pay in advance but also after the fact
5. The road pricing system should be accepted as being fair by its users
6. The road pricing system should be easily understood by its users
7. The equipment used to collect charges should be very reliable and not susceptible to fraud or evasion
8. The road pricing system should allow drivers from other areas to drive on roads where charges apply and to be able to pay those charges easily
9. Implementation should be gradual

Source: Data from United Kingdom 1964, 7-8.

Note: Numbering has been changed from the original numbers given to each bullet point in the original Smead Report.

4.1.2 Response to the Smead Report

Clifford Sharp was one person who was critical of the Smead Report, and wrote a 1966 *Economic Journal* article to discuss his concerns. Sharp writes that while the Smead Report is written as if it were primarily recommending pricing the use of roads in order to cover construction and maintenance costs, the Smead Report is actually advocating a congestion tax to reduce congestion (Sharp 1966, 807). Sharp also says that the Smead Report does not adequately suggest how revenues raised from a road pricing scheme should be used, and believes that the panel should have provided more specific ideas (Sharp 1966, 809). He goes on to point out that the economic benefits of the road pricing scheme are quite different if the generated revenues are used to fund public transportation, in which case those who lose as a result of the road pricing scheme could potentially turn into winners, as opposed to if the revenues are used to reduce existing motorist taxes (Sharp 1966, 811). Sharp also expresses concern that people's work schedules will be so inflexible that most will choose to not change their driving behavior or schedule and pay the toll, even if the toll rate is very high (Sharp 1966, 812). Another worry is that people who would rather take the train or bus instead of driving and paying the tolls would overwhelm the public transportation infrastructure (Sharp 1966, 815). Finally, Sharp is concerned that road pricing will affect commercial shipping and other business functions as trucks avoid the tolls or pass on the cost of paying the tolls to their clients (Sharp 1966, 813). The article concludes with Sharp saying that his concerns are not a basis upon which to reject the Smead Report, but that further examination of the ideas contained in the report was needed (Sharp 1966, 815).

4.1.3 Vickrey on Defense

In 1968, Vickrey published an article entitled *Congestion Charges and Welfare: Some Answers to Sharp's Doubts* to counter some of Sharp's criticisms of the Smead Report. Vickrey wrote that he believed that if the proper rate was established and charged, "there is very little case for license fees, and the fees can appropriately be reduced to a level representing administrative and other similar costs associated with registration" (Vickrey 1968, 111). Vickrey also said that public transportation would run more efficiently if congestion pricing was instituted due to the decreased congestion levels, and reminded Sharp that no one should be entitled to a discounted toll or total exemption from charges (Vickrey 1968, 115; Vickrey 1968, 117).

Although Sharp never specifically raises any potential equity issues, Vickrey also writes in this same article that he does not believe that road pricing will adversely affect lower income drivers, but that most of the trips to be affected by road pricing would be discretionary trips made by "the moderately well-to-do" (Vickrey 1968, 116). Additionally, those lower income travelers and other non-drivers who relied on public transportation would likely benefit from road pricing because their trips would be faster if vehicular traffic was reduced.

4.1.4 Continuing the Discussion

The Smead Report and the resulting responses from Sharp and Vickrey serve not only as an example of the type of discussions academics held in the short term following Vickrey's proposals, but also as an example of the types of discussions that have been held by decision makers since the 1950s. However, now that a framework for the types of discussions that have been held over the years has been established, it makes less sense to continue the chronological narrative of noteworthy writings about road pricing, and more sense to address the various aspects of the road pricing debate topic by topic. These topics include the costs of congestion, the underutilization of HOV lanes, the advent of public-private partnerships as a transportation financing method, and the incentives for non-users to support road pricing.

4.2 What Makes Road Pricing Attractive in the First Place?

What makes the concept of pricing individual road use so attractive to economists and transportation planners? Most of the impetus results from a desire to reduce or eliminate congestion on existing roads at peak travel times, although road pricing is also used as a financing tool. HOT lanes are seen as a way to reward carpoolers and public transportation riders while using the highway's infrastructure more efficiently than if the lanes were toll free HOV lanes. This next section analyzes each of these draws to road pricing.

4.2.1 The Rising Costs of Congestion

Although one may not think that a ten-minute delay caused by rush hour traffic on one's commute home is significant, when statistics are studied on an annual basis, the amount of time that we spend stuck in traffic in our cars as a society is staggering. Congestion raises labor costs and fuel costs for businesses, and individuals must spend more time commuting to and from work that could be spent with their families, at the workplace earning money, or engaged in leisure activities (United Kingdom 1964, 3). Tables 4.2 and 4.3 show the costs and other impacts resulting from increased congestion in the United States, which are the result vehicle miles traveled increasing 120 percent between 1982 and 2003, while the number of urban roadways in the United States has only increased 60 percent during the same period (U.S. Department of Transportation

Table 4.2: Costs of Congestion in the 85 Most Urban Areas of the United States

- Time incurred through travel delays each year: 3.7 billion hours
- Time spent each year stuck in traffic: Almost 8 full workdays
- Extra fuel used as a result of travel delays: 2.3 billion gallons
- Value of lost time and additional fuel costs: $850-$1,600

Source: Data adapted from U.S. Department of Transportation 2006, 1.

Table 4.3: Rising Costs of Congestion from 1982 to 2003		
	1982	2003
Percentage of traffic impacted by highway congestion	33%	67%
Duration of highway congestion per day	4.5 hours	7 hours
Additional time added to the length of the average rush hour driver's trip	13%	37%

Source: Data adapted from U.S. Department of Transportation 2006, 1.

2008, II-2). Congestion is generally attributed to "the lack of a mechanism to efficiently manage [the] use of capacity" (U.S. Department of Transportation 2006, 1).

4.2.2 Increasing Capacity to Meet Demand

Many people assume that the easiest and simplest way to reduce congestion is to construct additional travel lanes on the highway in question. However, in actuality, this is rarely a feasible option. In 2006, the average cost of adding one lane of highway in an urban area is $10 million (U.S. Department of Transportation 2006, 1). Gas taxes can only raise about $60,000 per year, and once the new lane is constructed, it provides even greater incentive for more people to use the newly constructed capacity (U.S. Department of Transportation 2006, 1). Therefore, creating additional supply by adding travel lanes to meet increased demand is rarely an optimal solution, and other solutions need to be considered instead.

4.2.3 HOV Lanes

4.2.3.1 A History of HOV Lanes in the United States

The idea of providing shorter trip times for those who helped reduce congestion has existed since the early 1970s. HOV lanes are supposed to increase capacity by encouraging carpooling and allowing carpools and other high occupancy vehicles to bypass congestion. In turn, this is supposed to reduce overall congestion, shorten trip times for those who carpool, and decrease vehicle emissions (Kwon and Varaiya 2007, 99; Dahlgren 2001, 1). However, carpools were not the original beneficiary of HOV lanes. Starting in 1971 during the morning rush hour, an outbound lane on New Jersey Route 495 was converted into an inbound lane for the use of buses only, reducing the trip time by up to 20 minutes when compared to the regular inbound traffic lanes (Port Authority of New York & New Jersey 2005, 1). At about the same time, a reversible two-lane facility opened on Interstate 395 in Northern Virginia for buses only (U.S. Department of Transportation 2008, II-2). Other bus only lanes were opened in other locations around the country shortly thereafter, but due to low utilization, many were converted to HOV-3 facilities (U.S. Department of Transportation 2008, II-2). However, HOV-3 facilities were also plagued by low utilization, so the minimum occupancy requirement on most HOV lanes was changed to two people (U.S. Department of Transportation 2008, II-2).

4.2.3.2 HOV Lane Underutilization

The continued underutilization of HOV lanes is one of the primary arguments used by their detractors for why HOV lanes should not be constructed or implemented. Currently, the federal government recommends that newly constructed HOV lanes allow any car with two or more occupants to use the lane (U.S. Department of Transportation 2008, III-1). However, HOV-2 does not necessarily encourage carpooling, and a number of studies show that HOV lanes are not used to their full potential. At the 11th international conference on HOV systems in 2002, many presentations discussed how HOV lanes were being used by fewer than 800 vehicles per hour and that average speeds were often below 45 miles per hour (Kwon and Varaiya 2007, 100). This means that few people were actually using the HOV lanes, and that those who did were often experiencing congestion while using the lanes; an explanation for how low use and low speeds could be experienced simultaneously is given in section 4.2.3.3.

Although the following research regarding the underutilization was carried out in California, the results and conclusions from this research can be applied to other locations as well. Throughout the State of California, a system of vehicle detector stations counts the number of cars using each lane of the highway at various locations throughout the state. These counts are then used to determine the average speed, volume, flow, and amount of delay resulting from congestion at that location (Kwon and Varaiya 2007, 102). Caltrans considers the capacity of its HOV lanes to be 1650 vehicles per hour per lane (Kwon and Varaiya 2007, 103). However, in 2005, over 80 percent of vehicle detector stations in HOV lanes were registering fewer than 1400 vehicles per lane per hour and thirty percent of the stations were registering fewer than 800 vehicles per lane per hour, presumably during peak periods (Kwon and Varaiya 2007, 103). During the afternoon peak period, the detectors indicated that nearly one third of the HOV lane miles in California offered a degraded level of service, meaning the average speed in the HOV lanes was less than 45 miles per hour; possible explanations for this are given in the next section (Kwon and Varaiya 2007, 103). However, trip times were more reliable in the HOV lanes than in the general purpose lanes, which means that drivers who used the HOV lanes made their trips each day knowing how long the trip will take with a greater degree of confidence than those who had to use the general purpose lanes (Kwon and Varaiya 2007, 105).

4.2.3.3 Explanations for HOV Lane Congestion & Underutilization

There are several possible explanations for why California's HOV lanes are both congested and underutilized, resulting in decreased time savings when compared to the general purpose lanes. Most HOV lanes are single lane facilities with no physical separation between the HOV lane itself and the general purpose lanes that are running alongside at a much slower speed (Kwon and Varaiya 2007, 104). Therefore, traffic in the HOV lane can only move as fast as the slowest vehicle in that lane is traveling. Some drivers in an HOV lane may feel uncomfortable driving at high speed when the adjacent lane is traveling at a much slower speed, while other slowdowns may occur when cars merge into and out of the general purpose lanes and have to slow down to be able to make that merge (Kwon and Varaiya 2007, 105).

Another possible explanation for the underutilization of HOV lanes is that the time savings from using an HOV lane are outweighed by the inconveniences associated with being part of a carpool. The fact that the federal government's initial requirement that HOV lanes be HOV-3 facilities had to be relaxed due to the low use of HOV-3 lanes indicates that commuters are reluctant to join carpools, and that still seems to be the case. As of 1993, forty-three percent of all carpoolers using HOV lanes were believed to be from the same household, and it is believed that many of these carpoolers would travel together even if the HOV lane did not exist along their commuting route (Fielding and Klein 1993). A 2000 report from the California Legislative Analyst's Office said that the nationwide average vehicle occupancy declined from 1977 to 1995 (Kwon and Varaiya 2007, 107). Both these statistics indicate that carpooling is perceived as being inconvenient and burdensome. Additionally, the number of carpool commutes in Southern California, which is where one-fifth of the United States' HOV lanes are located, decreased while the number of commutes made in a SOV increased between 2000 and 2004 (Kwon and Varaiya 2007, 107). However, surveys of Californians indicate that most people believe that they could save time while commuting if they carpooled (Kwon and Varaiya 2007, 108).

4.2.3.4 Solutions are Hard to Come By

Addressing the underutilization of HOV lanes is neither simple nor easy. In locations where HOV lanes are underutilized because too many people would rather drive alone in the general purpose lane than be part of a carpool, creating exemptions so certain SOVs, such as hybrid cars, can use the HOV lanes, can result in making so many people eligible to use the HOV lane that congestion ensues anyway. In other locations where the HOV lanes are overused, HOV-2 facilities could be redesignated as HOV-3 facilities. While this might create an additional incentive to carpool, it might also further decrease the utilization of the lanes (Fielding and Klein 1993). HOT lanes are often considered a good way to allow SOVs to utilize unused capacity in underutilized HOV lanes without creating additional congestion since the charge of the toll is adjusted to ensure that the lanes are free flowing at all times, but replacing HOV lanes with HOT lanes is often controversial and until recently, technologically unfeasible. However, the factors to consider when selecting between road pricing or congestion management options are more relevant to the discussion of selecting a method of implementation as opposed to why road pricing is attractive, and will be discussed in the section that discusses that selection process.

4.2.4 Public-Private Partnerships

As previously stated, the cost of adding one lane of highway in an urban area is about $10 million (U.S. Department of Transportation 2006, 1). Therefore, road expansion projects, however necessary they may be, are very expensive, often making it difficult for the public sector to finance and fund such projects on its own. However, the use of public-private partnerships as a project financing tool has become popular in recent years.

4.2.4.1 Transportation Financing Options

A variety of methods can be used to fund transportation programs, of which road pricing is one option. Other options include fuel taxes, dedicated sales taxes, and special property taxes (Victoria Transport Policy Institute 2008a). A more extensive list of financing options is given in table 4.4.

Table 4.4: Potential Sources for Funding Transportation Projects

- Parking pricing
- Special parking taxes
- Road pricing
- Fuel tax increases and surcharges
- Carbon taxes
- Dedicated local or regional sales taxes
- Transportation impact fees
- Special Property Taxes
- Vehicle impact mitigation fees
- Business or Employee Assessments
- Grants
- Special Funding for Transportation Problem Solving

Source: Data adapted from Victoria Transport Policy Institute 2008a.

4.2.4.2 Public versus Private Financing

Projects can be funded through either the public or private sector. Public sector projects tend to rely on money raised through taxes as a funding source, whereas private sector projects are often reliant on user fees in order to recoup the costs of construction (Victoria Transport Policy Institute 2008a). There are advantages and disadvantages associated with each option. Projects funded with public money are often less expensive and have a tendency to better fit in with the long term plans of the larger community (Victoria Transport Policy Institute 2008a). Privatized projects are less likely to get mired in governmental bureaucracy and labor regulations, which means that the projects can be completed faster and with fewer complications (Victoria Transport Policy Institute 2008a; Morris 2006, 19; U.S. General Accounting Office 2004, 15; Gómez-Ibáñez and Meyer 1993, 275). However, privatized operations usually need to break even or turn a profit in order to be successful, which can result in user fees on a facility being set to maximize revenue and not the overall well-being of society (Victoria Transport Policy Institute 2008a). The public sector can also lose the ability to make infrastructure improvements that might hurt the private sector's potential revenues (U.S. General Accounting Office 2004, 17). An example of how this situation occurred and how it was resolved is given in the next section.

4.2.4.3 Public-Private Partnerships: Combining Elements of Both Financing Options

A public-private partnership, as defined by the Federal Highway Administration, is an agreement "formed between a public agency and a private sector entity that allow[s] for greater private sector participation in the delivery and financing of transportation projects" (U.S. Department of Transportation 2009, Public Private Partnerships). The supposed advantage to this arrangement is that in many cases, without the financial contributions of the private firm or consortium, the road expansion or construction would not occur because the public sector does not have enough money to fund the project on its own. Examples of roads where this type of arrangement was used, is currently used, or will be used are California State Route 91, Highway 407, and the Interstate 495 and Interstate 95/395 HOT Lanes.

However, engaging in public-private partnerships carries risks for both the public and private sector stakeholders involved in such a project, including inadvertently making agreements with the private firms that are not in the interest of the traveling public. Three places where this has happened are on California State Route 91, Highway 407 in Ontario, and Interstate 95/395 in Northern Virginia.

When California awarded a franchise to the California Private Transportation Company (CPTC) to construct the Route 91 HOT lanes in 1990, the contract included a non-compete clause that did not allow public agencies to add additional capacity in the Route 91 corridor, since additional capacity would reduce demand for the HOT lane (Richardson et al. 2008, 343). However, as volume in the Route 91 corridor continued to increase, the state insisted on being able to expand capacity in the Route 91 corridor, and a dispute between CPTC and the state ensued. The conflict was resolved when CPTC sold the HOT lanes to the Orange County Transportation Authority, putting the public sector in control of the Route 91 HOT lanes and enabling additional general purpose lanes to be constructed (Richardson et al. 2008, 343; Orange County Transportation Authority 2008a).

When Highway 407 was leased to a private operator for 99 years in May of 1999, one of the conditions of the lease was that the private operator could charge tolls and set the toll rates without government approval for the duration of the lease period (Mylvaganam and Borins 2004, 88). The private operator was also allowed to charge tolls even after the highway's construction was paid for, which is when the tolls were originally scheduled to be removed (Mylvaganam and Borins 2004, 90). Since privatization, tolls on Highway 407 have increased at a rate much faster than originally predicted by the government when the road was constructed (Mylvaganam and Borins 2004, 94). Although the increases have remained within the terms set in the highway's lease, public servants who served on the steering committee that planned the highway's sale regret not being able to include a mechanism by which to regulate tolls into the lease (Mylvaganam and Borins 2004, 83). Additionally, the length of the lease has been criticized as being far too long. Most other highways were being leased for no more than 30 years at the time Highway 407 was privatized, and the government received little financial benefit as a result of a longer lease (Mylvaganam and Borins 2004, 87).

Finally, the Interstate 95/395 HOT lane operator, Fluor-Transurban, must ensure that traffic maintains a minimum speed of 45 miles per hour, even though the existing HOV facility on Interstate 95/395 has an average speed of over 60 miles an hour (Tuss 2009). Although the government awarded the contract to Fluor-Transurban with the supposed intention of improving travel times, it appears likely that a significant number of people will be negatively impacted if Fluor-Transurban attempts to maximize revenue and allows speeds on the HOT lanes to drop to 45 miles per hour.

In all three of these cases, the public interest was not served as a result of some of the terms of the public-private partnership. While there are risks involved for a private firm that is considering entering into such a partnership, there is an incentive to accept these risks if congestion on what would be the toll-free alternate routes is high (Richardson et al. 2008, 353). However, if governments must bend over backwards to create this type of incentive, the practicality of using a public-private partnership as a financing tool should be reevaluated.

4.2.5 Benefits for Non-Users

4.2.5.1 Benefits for Business

Many existing HOV and HOT lane facilities do not permit trucks to use the lanes within those facilities (Kawamura 2003, 65). However, commercial traffic, such as trucks, benefits from the presence of those types of facilities even when prohibited from using them. A variable road pricing scheme designed to decrease overall congestion has the potential to lower the costs of shipping and making deliveries for businesses because as trip times are reduced, the time savings resulting from the congestion charge may be more valuable than the charge itself (Small 1992, 361). However, even when trucks are unable to use HOV or HOT facilities, they still benefit from their existence.

A study of truck use on California State Route 91, which has a HOT lane, estimated the economic benefits gained under the current rules where trucks are banned from the HOT lane, based on the volume totals for trucks and all other vehicles. The data on volumes were provided by Caltrans (Kawamura 2003, 60). A model was then used to simulate the decision making process of each vehicle, including trucks, where if the value of the vehicle's time was greater than that of the toll being charged at that time, the vehicle used the HOT lane (Kawamura 2003, 61). The simulation was also run to simulate conditions when commercial vehicles are banned from the HOT lane (Kawamura 2003, 61). The study showed that in 1996, one year after the Route 91 HOT lane opened, the presence of the HOT lane created $2 million in time savings benefits for the trucks (Kawamura 2003, 63). This is because even though trucks were not allowed to use the HOT lanes, conditions in the general purpose lanes improved as a result of the opening of the HOT lane An additional $660,000 in time savings benefits would have been gained if trucks were allowed to use the HOT lane with a $3 toll (Kawamura 2003, 63).

4.2.5.2 Benefits for Public Transportation

Road pricing can also benefit and encourage the use of public transportation. In London, following the implementation of the London Congestion Charging Scheme (LCCS) on February 17, 2003, traffic within the congestion charging zone has decreased by about 20 percent, the speeds of buses in Central London have increased, bus ridership has increased 14 percent, and delays have been reduced by 60 percent (Banister 2008, 186; U.S. General Accounting Office 2003, 11; Glaister and Graham 2004, 46). Public transportation vehicles can also make use of HOV or HOT lanes where they are provided, providing passengers with reliable trip times and a means by which to bypass congestion. Using the revenue earned from road pricing projects to fund public transportation improvements is a practice that is often suggested and implemented, and is discussed further in section 5.3.5.3.

CHAPTER 5: IMPLEMENTING A ROAD PRICING SCHEME

5.1 Methods of Road Pricing Implementation

5.1.1 Types of Road Pricing

There are several basic methods, including HOT lanes and cordons, that planners and officials can use to implement a road pricing scheme. These are defined in the glossary. It is also important to know the different scales at which road pricing schemes can be implemented, these are defined in table 5.1. While no two pricing schemes are exactly alike, schemes do share certain core characteristics with each other at their most basic level.

Table 5.1: Scales at which Road Pricing can be Implemented

Term	Definition	Example
Point	Pricing a particular point in the road network	George Washington Bridge, New York, NY
Facility	Pricing a roadway section	New Jersey Turnpike
Corridor	Pricing all roadways in a corridor	
Cordon	Pricing all roads in an area, such as a central business district	London Congestion Charging Scheme
Regional	Pricing roadways at regional centers or throughout a region	Seattle VMT Pricing Experiment

Source: Data adapted from Victoria Transport Policy Institute 2008b.

5.1.2 Picking the Proper Option

The biggest challenge that decision makers attempting to implement a road pricing scheme face is creating a scheme that not only meets its primary objective, such as paying off construction costs or reducing congestion, but implementing a scheme that is acceptable to the traveling public and perceived as being fair to all users.

5.1.2.1 HOV Lanes versus HOT Lanes: Where to Implement Each Type

Generally, HOT lanes are proposed for expansions of roadways that are at or over capacity. If the primary goal of the decision makers involved is to expand the road and reduce congestion while retaining an incentive to carpool, then HOT lanes should be chosen (Dahlgren 2001, 1). The primary advantage to HOT lanes over HOV lanes is that they continue to provide an incentive to carpool by providing free trips to HOVs, but they can also be utilized by SOVs and generate revenue through the collection of tolls from SOVs (Dahlgren 2001, 1). One way to evaluate whether a general purpose lane, HOV lane, or HOT lane will reduce congestion the most on a highway is to use a queuing model (a model used in queuing theory to simulate or analyze behavior as a result of needing to form a queue in order to use a facility or to receive a service) in conjunction with a logit model to determine the probability of an individual being a passenger in a HOV as opposed to a SOV (Dahlgren 2001, A-3). However, a queuing model cannot be designed to simulate drivers' reactions to the toll charged on a HOT lane, nor can it account for shifts to or from the highway being expanded as a result of the construction of a HOV lane or HOT lane (Dahlgren 2001, 4). Other assumptions have to be made as well; these are outlined in table 5.2. However, despite these flaws, a queuing model can still be a good indicator of what type of expansion should occur.

In addition to the aforementioned flaws in using a queuing model that have been outlined, every highway has different flows and lengths of time at which congestion is experienced. When Joy Dahlgren developed the queuing and logit models described in her 2001 paper, *The Prospects for High Occupancy/Toll (HOT) Lanes: Where They Should be Implemented*, she made several assumptions that are outlined in table 5.3 that have to be modified to fit the parameters of each specific project where these types of queuing and logit models are to be applied. Dahlgren ran the queuing model six times,

Table 5.2: Effects of Assumptions in Dahlgren's Queuing Model

Assumptions That Lead to an Overstatement of the Benefits of an HOV Lane Relative to a Mixed flow Lane	
Identical probabilities of using an HOV	The mode shift with identical probabilities is always greater than with different probabilities
No downstream entries	Downstream entries cause measured delay to be more than actual average delay--more delay favors an HOV lane
No reduction in convenience due to shift to HOV	Only the time saving beyond that necessary to induce a shift is a benefit
All HOVs use the HOV lane	Benefits of HOV lane are less if fewer vehicles use it
People do not drive to meet the carpool or bus	Driving to meet the carpool or bus would increase emissions substantially
Assumptions That Do Not Change the Ranking of an Added HOV Lane Versus an Added Mixed flow Lane	
No route shifts	Benefits are larger with larger route shifts, and larger delay reductions result in larger route shifts
No shifts in trip start time	Larger delay reductions allow larger shifts in trip start times
No induced trips	Benefits from new trips are greater and costs of these trips are less with larger reductions in delay. Air quality benefits of reduced delay are likely to be greater than air quality costs of induced trips
No vehicles entering and exiting the queue before the bottleneck	Benefits to these vehicles are greater with larger reductions in delay
Assumptions Whose Effects Depend on the Situation	
Vehicles arrive at a constant rate until the time of maximum delay and at a lower constant rate Thereafter	If the arrival rate is linearly increasing and the time of maximum delay is less than 2/3 through the peak period, the relative benefits of an HOV lane will be understated; otherwise they will be overstated
Only HOVs use the HOV lane	Allowing cheating increases utilization of the HOV lane but reduces the incentive to use an HOV

Source: Data from Dahlgren 2001, table A1.

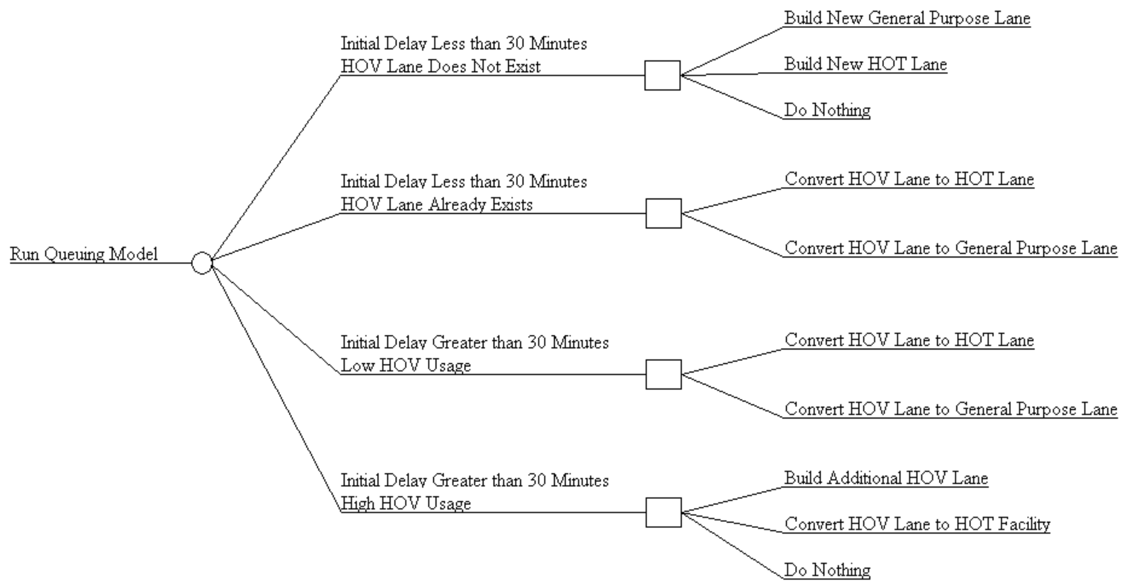
Table 5.3: Parameters for Dahlgren's Queuing Model

- Maximum flow for general purpose lanes is 2000 vehicles per lane per hour
- Freeway initially has 3 lanes
- Congested period before lane is added is three hours
- Travel time increases at constant rate until middle of the congested period and then falls at a constant rate until end of congested period
- Carpool occupancy rate is 2
- All HOVs use the HOV or HOT lane
- Only HOVs use the HOV lane and only HOVs and toll paying vehicles use the HOT lane

Source: Data adapted from Dahlgren, Joy 2001, 2.

with varying initial percentages of HOVs and maximum delay times, and found the following results. If the initial maximum delay is less than 30 minutes, an additional general purpose lane will sufficiently reduce congestion and is the least expensive option to construct (Dahlgren 2001, 6). However, an additional HOT lane will reduce congestion as much or more than an additional HOV lane or general purpose lane in any circumstance (Dahlgren 2001, 6). If an underutilized HOV lane already exists, congestion can be reduced by converting that HOV lane to either a general purpose or HOT lane, with the determining factor being whether there are a high proportion of HOVs traveling on that highway already or not (Dahlgren 2001, 6). In other words, if there are not many potential HOV HOT lane users, the HOV lane should be converted to a general purpose lane as opposed to a HOT lane because very few people would be eligible to use and benefit from the HOT lane if it was created under these circumstances. A decision tree that summarizes the results of Dahlgren's research is shown in figure 5.1.

Figure 5.1: HOT Lane versus HOV Lane versus General Purpose Lane Decision Tree



Source: Data adapted from Dahlgren 2001.

5.1.2.2 Cordons and Congestion Pricing Zones

A cordon toll, such as the LCCS or Singapore's Electronic Road Pricing, is paid as a driver enters a designated area (Victoria Transport Policy Institute 2008b). The toll is usually paid using electronic toll collection as drivers pass the cordon limits, or by requiring drivers to pay for a permit in advance and displaying it at all times while driving within the cordon, since as Vickrey wrote, having a toll booth at each and every entry point to the tolled area is infeasible and impractical in practically all circumstances (Vickrey 1994b, 312). However, cordons are not usually able to charge for travel that occurs entirely within the tolled zone (Lindsey 2007, 13).

According to the independent Road Charging Options for London (ROCOL) research group, cordons are most effective in areas where the overwhelming majority of travelers are not drivers, though the methods used to reach this conclusion are unclear

(Lee 2008, 219). In London, over eighty percent of people who entered central London prior to the LCCS implementation were non-drivers and were unaffected by the congestion charge. In the United States, only 12 percent of the population is non-drivers, and even in the five boroughs of New York City, which has one of the highest public transportation usage rates in the country, only 60 percent of commuters are non-drivers (Lee 2008, 219). As a result, cordons will rarely be the chosen road pricing option in the United States, but they should still be considered for some locations, such as Manhattan in New York City.

Other factors must also be considered as well, and they will be discussed later in this chapter. These topics include setting an appropriate toll rate and equity concerns.

5.1.2.3 An Alternative Form of Road Pricing

HOT lanes and cordons are useful congestion management tools. However, it should be noted that there are other means by which drivers can be made to pay for their actual road use and the costs of congestion each individual driver imposes upon others. The primary method used to charge individual drivers for their road use in the United States is the gas tax. While one may assume that this is an equitable tax since those who drive more will need to buy more gas and pay more taxes, the gas tax "poorly conforms to the actual cost of building, maintaining, and operating facilities at maximum effectiveness" (Ungemah 2007, 15). The gas tax is also not high enough to encourage drivers to change their travel schedules, driving route, or modal choice, as indicated by the fact that higher income households use their cars more often and travel further than lower income households (Ungemah 2007, 16; Bae and Mayeres 2005, 174). Finally, since different vehicle models get different gas mileages and cause different types of wear and tear on road surfaces, the gas tax does not actually correlate to a driver's individual road use and tax it accordingly (Bae and Bassok 2008, 315). Charging drivers for each mile they actually drive with global positioning systems (GPS) is an idea that has been tested in the Seattle area, and also has been proposed by Transportation Secretary Ray LaHood (Bae and Bassok 2008; Weiss 2009b).

The Seattle experiment was a federally funded road pricing pilot project that used GPS technology to determine toll rates (Bae and Bassok 2008, 313). While underutilization of HOV lanes is a problem in many areas, most of Seattle's HOV lanes are congested (Bae and Bassok 2008, 314). Additionally, since 1980, the number of vehicle miles traveled (VMT) has increased at a much faster rate than the population of that area has increased, and highway capacity has remained practically unchanged (Bae and Bassok 2008, 317). Volunteers were randomly selected to have a GPS transponder installed in their car, and received an "endowment account" from which to draw funds for the duration of the pilot program so that none of the tolls paid as part of the project would actually come out of the volunteers' pockets (Bae and Bassok 2008, 320). The pilot ran from January 2005 until the end of June 2006, and tolls varied based on the time of day that the trip was made and whether the route used freeways or other roads (Bae and Bassok 2008, 323).

There were two important results from this experiment. The first is that it is feasible to use GPS or another satellite based technology to charge tolls as part of a road pricing scheme. The second is that the pilot showed that charging tolls can affect people's behavior, although the results may be distorted by the fact there were no out of pocket costs from any of the pilot program's volunteers (Bae and Bassok 2008, 323).

Drivers avoided roads with the highest tolls and most congestion, and vehicle miles traveled by the pilot program volunteers decreased over the course of the pilot (Bae and Bassok 2008, 323).

Mileage based taxing has support among some government officials, including Transportation Secretary Ray LaHood, who told the Associated Press in a February 20, 2009 interview that "We should look at the vehicular miles program where people are actually clocked on the number of miles that they traveled," and that he was opposed to increasing the gas tax (Weiss 2009b). However, many of the potential issues with road pricing in general, including privacy and equity concerns, also apply to GPS based tolling.

5.2 Changes in American Road Financing Policy

It is necessary to take a moment and provide a brief history of changes to United States laws and policies that facilitated the use of federal funds to construct toll facilities. As previously mentioned, the IHS was built without tolls, and it was practically impossible to obtain federal funds to use on the construction of toll roads. However, beginning in the 1970s, the federal government began, albeit slowly, to change its stance on road pricing.

In 1976, Transportation Secretary William Thaddeus Coleman, Jr. wrote to several mayors to inquire if their cities were interested in testing a road pricing scheme, similar to the Singapore Area Licensing Scheme that had started in 1975 (Rye and Ison 2008, 286). The only cities to express any interest in the program were Berkeley, CA, Madison, and Honolulu, and these cities tested road pricing schemes in 1976 and 1977 (Rye and Ison 2008, 286). However, none of these tests was successful, and the public opposed the regressive taxation element of road pricing, its restrictions on travelers' mobility, and the negative economic impacts that were predicted as a result of implementing such a scheme permanently (Rye and Ison 2008, 286).

Attempts to introduce road pricing in the United States then shifted to the state level. In 1989, California Bill 680 was passed, permitting the private sector to finance new road construction in that state (Rye and Ison 2008, 286). The first road to be built with such funds was the California State Route 91 HOT lane facility that opened in 1995 (Sullivan 1998). However, in 1991, the federal government reestablished its interest in exploring road pricing with the passage of the 1991 Intermodal Surface Transportation Efficiency

Figure 5.2: Federal Funding of Road Pricing Timeline

1976: Transportation Secretary Coleman writes to several cities to invite cities to participate in road pricing pilot programs modeled after Singapore's Area Licensing Scheme, response is tepid but three cities are interested
1976-1977: Pilots take place in Berkeley, Madison, and Honolulu, all the tests are unsuccessful due to lack of public acceptability
1978-1990: Federal government does not actively attempt to initiate further road pricing pilots
1989: California Bill 680 is passed, permitting the private sector to finance new road construction
1991: 1991 Intermodal Surface Transportation Efficiency Act is passed, marking the resumed interest by the federal government to explore the feasibility of road pricing
1995: California State Route 91 HOT lanes open, these lanes were the first project to be completed using the type of private sector financing authorized in California Bill 680
1998: 1998 Transportation Efficiency Act (TEA) is passed, making matching federal funds available for road pricing projects
2001: TEA-21 is passed, continues to make matching federal funds available for road pricing projects
2004-2008: About $11 million dollars in federal funds is allocated to road pricing programs each year
2005: SAFETEA-LU is passed, continues to make matching federal funds available for road pricing projects, and is the guiding legislation for road pricing projects at this time (March 2009)
Present (May 2009): SAFETEA-LU is the guiding legislation for road pricing

Sources: Data adapted from Rye and Ison 2008; U.S. Department of Transportation, Federal Highway Administration 2008.

Act. The 1998 Transportation Efficiency Act (TEA), the 2001 TEA-21, and the 2005 SAFETEA-LU all made matching federal funds available for road pricing schemes, with about $11 million in federal funds being allocated to such programs each year between 2004 and 2008 (U.S. Department of Transportation 2008; III-1; Rye and Ison 2008, 287). Cities that have received some of that federal money to experiment with road pricing in recent years include New York, San Francisco, Minneapolis, Miami, and Seattle (Layton and Hsu 2008).

5.3 The Key Elements of a Road Pricing Proposal

There are several essential components that a road pricing proposal must either include or be aware of in order for the proposal to be well received by both decision makers and the traveling public. Generally, the most successful road pricing projects effectively addressed these issues, whereas most failed or controversial projects did not account for or overlooked one of these key elements.

Table 5.4: Some Key Elements of a Road Pricing Proposal

Highway → **↓ Road Pricing Element**	**Highway 407**	**CA SR91**	**I-15 (CA)**	**I-394 (MN)**	**LCCS**
• Potential Funding Source					
o Toll Revenue	✓				
o Public Private Partnership		✓			
o Federal/State/Local Government			✓	✓	✓
• Setting Toll Rates					
o Preset Rates	✓	✓			✓
o Variable Rates			✓	✓	
• Electronic Toll Collection	✓	✓	✓	✓	✓
o Transponder Required for Access		✓	✓	✓	

Highway 407 is located in Ontario, Canada in the Toronto suburbs
CA SR91 is California State Route 91
LCCS is the London Congestion Charging Scheme

Sources: Data adapted from Mylvaganam and Borins 2004; Richardson et al. 2008, 343; Orange County Transportation Authority 2008a; San Diego Association of Governments; Buckeye and Munnich 2006; Lee 2008; Santos 2008.

5.3.1 Financing

Any proposed addition or expansion to transportation infrastructure requires a funding source to provide money to fund the construction of the project. There are a variety of costs that need to be covered and a variety of ways by which these costs can be paid for, and determining how this will be done is one of the first steps that must be undertaken when developing any pricing proposal.

5.3.1.1 Expenses to Cover

The costs of constructing HOT lanes within the median of an existing highway's right-of-way can be very high. A HOT lane construction project has some components that must be built as part of any HOT lane facility, as well as other components that are not necessarily going to be a part of every facility. Therefore, construction costs can vary based on what components are needed for a specific facility, with the total cost for one lane-mile being over $43 million based on estimates provided by the Federal Highway Administration, as shown in table 5.5 (DeCorla-Souza 2005, 29).

Table 5.5: Cost Estimates for HOT Lane Components from the Federal Highway Administration
(All costs are per mile and in millions of dollars)

Item	Cost	Required on all Projects
Additional lane	$10	Yes
Lane Separation	$2	No
Interchange Modification	$20	No
Access Ramps to HOT Lanes	$10	No
Toll Collection Equipment*	$1	Yes
Additional Maintenance Costs**	$0.05	Yes
HOT Enforcement Costs	$0.01	Yes

*-Estimate includes vehicle transponder costs
**-Additional maintenance costs are calculated for anything above the expense of choosing the "do-nothing" option

Source: Data adapted from DeCorla-Souza 2005, 29.

5.3.1.2 Potential Funding Sources

In the United States, interstate highways are funded with 90 percent of the funds coming from the federal government and 10 percent of the funds coming from state and local governments (Moon 1994, 10). However, as section 5.2 describes, any road that was constructed with federal funds had to be free of tolls until fairly recently. Therefore, adding HOT lanes to interstate highways was not possible. Now that HOT lanes and other tolled facilities, such as bridges, can be built on the IHS, charging a toll to raise all the money for a project is now an option for planners. Once the project has been paid for in full, the tolls can be removed; in some states, this is law (Bae and Bassok 2008, 314). The advantage to using toll revenues to fund a project in its entirety is that only those who actually use the highway help to pay for its construction. The public is also generally accepting of tolls that raise money that raise money to fund the road on which they are charged. Although it is not in the United States, Highway 407 in Ontario, Canada, prior to being privatized, is an example of a road where tolls were to be charged to finance the highway construction and removed once the project had been paid off (Mylvaganam and Borins 2004, 15). Another financing option, previously discussed in section 4.2.4, is the use of public-private partnerships.

5.3.2 Setting Toll Rates

The actual toll charged in a congestion pricing scheme is critical to the success of the scheme. If economics and marginal costs were the only factor to consider in setting toll rates, then the cost of using a HOT lane would be equal to the marginal social cost of each trip and its impact on other travelers, plus the cost of collecting the toll itself, which is what William Vickrey himself suggested (Victoria Transport Policy Institute 1992).

However, in actuality, there are a number of factors that must be considered in setting the toll rate.

5.3.2.1 Priorities in Setting Toll Rates

Road pricing can serve to achieve one of several objectives. These are welfare maximization, welfare maximization with a revenue constraint (also known as second best pricing), or profit maximization (Holguín-Veras, Cetin, and Xia 2006, 854). If decision makers were looking to apply Vickrey's theories to setting toll rates, they would want to pick welfare maximization, which is when the toll rate equals the increased cost of congestion resulting from an additional car on a network (Holguín-Veras, Cetin, and Xia 2006, 853). Profit maximization would be chosen if the purpose of the toll was to pay off the construction of the highway itself. At present, most tolls in the United States are set to maximize revenue for the collection agency, which results in the existing highway infrastructure not necessarily being used in the most efficient manner possible (Holguín-Veras, Cetin, and Xia 2006, 869). A decision about whether to set tolls to maximize welfare, revenue, or a combination thereof is entirely dependent upon the intended use of the toll revenues and the overarching goals of the road pricing scheme. Additionally, if welfare maximization is to be the guiding principle for setting the toll rate, an accurate estimate must be made for how much people value their time.

5.3.2.2 Variable Tolls

In his original proposal, Vickrey questioned why the principle of providing a discounted price during off peak hours could not be applied to transportation systems in the way that off peak discounts are provided at movie theaters and hotel resorts (Vickrey 1994b, 307). Under variable pricing schemes, tolls are set so that the rate changes based on a predetermined schedule, or "dynamically" in response to the conditions at any given moment. In the latter case, these factors can include the total demand for the HOT lanes and parallel general purpose lanes, the number of toll exempt HOVs using the lane, the difference in delay between the HOT lanes and general purpose lanes, and drivers' value of time (Dahlgren 2001, 7). An example of a road where the tolls are predetermined but vary on a set schedule is Highway 407 in Ontario, whereas on the Interstate 15 Express Lanes in San Diego, the toll rate is changed every six minutes in response to the actual demand for the highway at a given moment (407 ETR; Brownstone et al. 2002). Electronic toll collection systems make variable toll schemes feasible and easy to implement, and also save money in terms of the costs of collecting tolls; this will be discussed further in the next section (Levinson 2002, 186). Regardless of how the toll is set, drivers should be made aware of what the toll rate is prior to entering the HOT lane so they can decide if they want to pay the amount that is being charged, or if they would rather drive in the toll free general purpose lane.

5.3.2.3 Electronic Toll Collection

Collecting tolls electronically using electronic toll collection (ETC), as opposed to erecting toll booths and employing staff to manually collect the tolls, has become very popular in recent years; seventy percent of toll facilities in the United States utilize ETC (Holguin-Veras, Cetin and Xia 2006, 858). ETC is also the only viable way by which to implement variable road pricing schemes, including dynamic schemes, or road pricing that is dependent upon cordons, such as the LCCS (Santos 2008, 161). However, only six percent of toll facilities with ETC in the United States have variable or dynamic pricing (Holguin-Veras, Cetin and Xia 2006, 858). ETC often uses transponders mounted on the vehicle windshields that communicate with the tolling system and deduct the toll from the account associated with that transponder. ETC is preferred by toll collectors because it reduces the costs of toll collection. While many older highways have a combination of electronic and manual toll collection, fully electronic toll collection on highways is a much more recent development. However, such highways also need a system by which vehicles without transponders, such as those that only use the highway on an infrequent basis, can use the facility; it is usually to the advantage of frequent users to obtain a transponder since most agencies charge lower tolls for transponder equipped vehicles. Highway 407 was the first highway in the world to have fully electronic tolling; vehicles without transponders have their license plates photographed and the bill is mailed to the address on the vehicle's registration file; vehicles without transponders pay a higher toll than vehicles with transponders (Mylvaganam and Borins 2004, 41; 407 ETR).

Many existing HOT lanes in the United States, including the Interstate 15 Express Lanes, require SOVs to have a transponder in order to use the HOT lane (San Diego Association of Governments). Unless all cars are manufactured with transponders or some other type of electronic identifier, decision makers should use ETC systems that include license plate identification systems to allow infrequent users without a transponder access to HOT lanes or other fully electronically tolled roads. Although these systems require additional expenses, these additional expenses can be passed on to the drivers who lack transponders, as is done in Toronto. The surcharge that comes as a result of not having a transponder should serve as an incentive for frequent users to obtain a transponder. Additionally, an effort should be made to ensure compatibility between transponders issued by different tolling authority, so a driver can have one transponder that works on many different roads as opposed to a separate transponder for each road (Levinson 2002, 187).

5.3.3 Using Toll Revenues

One of the largest hurdles that decision makers and proponents of road pricing must pass is that the traveling public wants to know how the toll money will be used once it is collected, in the event that the toll rates are not set with welfare maximization as the only goal. Revenues can be used for a variety of purposes, as outlined in the remainder of this section. The exact split between these potential revenue uses needs to vary from scheme to scheme based on the stated goals and other funding needs of each particular road pricing scheme.

5.3.3.1 Transportation Improvements

Road pricing initiatives are often supported by those who believe that only those who use roads or cause congestion on those roads should pay the costs required to build and maintain those roads. Therefore, many feel that any toll revenue raised through road pricing should only be used to fund transportation related projects, and doing so satisfies the “beneficiary principle” that taxes should be paid in proportion to the benefits received from public services (Lindsey 2007, 14). The public at large, including drivers, the construction industry, and many landowners, is often very supportive of paying tolls collected with the goal of paying off the cost of building a road or expanding that road (Small 1992, 368). Prior to privatization, Highway 407’s tolls were to be removed once the project had been paid for in full (Mylvaganam and Borins 2004, 27). Someone who never drives on Highway 407 does not contribute to funding the construction of the highway.

Revenues can also be directed to funding other transportation initiatives and improvements, such as public trains and buses, park and ride lots, and ridesharing incentives. Using the revenues to fund public transportation can be seen as a way to reward those who use public transportation to avoid paying road pricing fees, and also to pay for extra vehicles and additional service should modal shifts warrant such increases (Small 1992, 369). Money can also be used to construct park and rides in the corridor with the HOT lane, or for general transportation related projects such as street repairs and cleaning, improved street lighting, sidewalks, bicycle paths, and the like (Small 1992, 369).

5.3.3.2 Reducing Taxes

Drivers currently pay vehicle registration fees and gas taxes to help fund programs such as the Highway Trust Fund (Moon 1994, 10). These taxes and fees are often considered to be the user fees for general road use. However, the gas tax and vehicle registration are not charged to individual drivers in a way that reflects actual road use for a variety of reasons (Small 1992, 367). Different vehicles get different gas mileages, so a hybrid driver can drive the same distance as an SUV driver and pay significantly less in gas taxes. Additionally, a gas tax is a regressive tax because vehicle ownership and use rises less than proportionally when compared to income level (Small 1992, 367). Vehicle registration fees are higher in some states than in others, yet once these fees are paid, a driver can drive in any state he or she chooses. If road pricing is meant to be used as a system by which drivers are made to pay for the impacts of their own personal road use as Vickrey envisioned, then road user fees need to be charged in a way that places a premium rate on heavily traveled routes during rush hour or on charging drivers for the actual number of miles they drive. If that occurs, it is suggested that gas taxes and vehicle registration fees be reduced.

5.3.3.3 Other Potential Uses

There are other options for how to use the revenues besides those already mentioned. These include removing sales taxes that are dedicated to funding transportation projects, rebating a portion of property taxes, and creating an allowance based credit program (Small 1992, 366-368). Decreasing the sales tax or rebating property taxes are ways to ensure that only those who use the transportation infrastructure pay for the costs of constructing and maintaining it. The allowance based credit system is a means by which to mitigate equity concerns and the potentially negative impacts of introducing road pricing into an area and will be discussed more at length in section 5.3.5.3, which pertains to equity issues.

5.3.3.4 Arguments for not Designating Specific Revenue Uses

There is a risk to earmarking revenues in advance, which is that spending priorities may change over the course of time, and therefore, it is not advantageous to permanently earmark funds too long before they are actually going to be used (Lindsey 2007, 14). However, taking this approach runs the risk of losing public support for the road pricing project because of the uncertainty concerning how the money will be used once collected. Another risk is that funding from other sources may be reduced if revenues are earmarked in a specific way, as allegedly occurred in London after that city’s congestion pricing scheme was put into effect (Lindsey 2007, 14).

5.3.4 Public Involvement

Public acceptability is generally considered to be the most significant barrier faced when trying to implement a road pricing scheme (Lindsey 2007, 15). However, surveys of travelers in corridors where pricing is currently used taken before and after implementation show that once a scheme is successfully implemented, road pricing is generally approved of by the traveling public. Examples of road pricing applications where this has occurred include the Interstate 394 HOT lane and California State Route 91 HOT lane (Buckeye and Munnich 2006, 86; Ungemah 2007, 15). The challenge is convincing the public, which is initially skeptical of these proposals more often than not, that road pricing will be beneficial to them once it is implemented. According to Professor John M. Bryson at the Hubert H. Humphrey Institute of Public Affairs, when stakeholders' concerns and needs have been ignored or underestimated, projects have performed poorly or failed entirely whereas they could have been successful had the proper steps been taken during the planning and implementation phases (Bryson 2004, 23). Additionally, "the right…to be involved in decisions affecting oneself, family, and community" is considered to be a fundamental of social inclusion, "the process by which efforts are made to ensure that everyone…can achieve their potential in life" (Rajé 2003, 323).

5.3.4.1 Identifying Winners and Losers

At a general level, there are basic groups of people who can be expected to "win" or benefit as a result of road pricing being implemented, either because they will benefit from experiencing less congestion even before revenues are actually distributed, or from the way in which toll revenues are used (King, Manville and Shoup 2008, 361). This can include solo drivers who value their time at a higher rate than the toll itself and solo

Table 5.6: Examples of Road Pricing Winners and Losers for Hypothetical HOT Lane Implementation

Status Prior to HOT Lane Implementation	Action in Response to HOT Lane Implementation	Result
Solo Driver	Uses HOT Lane as SOV because toll is valued at lower rate than drivers' time	Winner
Solo Driver	Joins carpool or begins to use public transportation, trip time reduced in comparison to travel time in SOV prior to HOT lane implementation	Winner
Carpooler or Public Transportation User	Continues to carpool or use public transportation	Winner
Solo Driver	Continues to drive SOV in congested, toll free general purpose lanes	Loser
Solo Driver, carpooler, or public transportation users on different, nearby highway that remains toll free	Continues to drive SOV on same route following HOT lane implementation	Loser (if congestion increases on this highway as a result of HOT lane implementation on the first highway)
Solo Driver	Begins to carpool or use public transportation to avoid paying tolls but trip takes longer as a result	Loser

Sources: Data adapted from Small 1992, 361-363; King, Manville and Shoup 2008, 361.

drivers who begin using an alternate mode that benefits so much from the road pricing scheme, such as a carpool, that the improved mode is now superior to being a SOV driver, and those who are already using public transportation and carpools whose trips will take no longer or less time than when there was no road pricing (Small 1992, 362). On the other hand, needing to change one's behavior in response to the road pricing scheme or the inconvenience of paying the toll itself can result in one being a loser (Small 1992, 361). This group includes solo drivers who choose to pay the toll as opposed to changing modes or driving during a time at which the toll is reduced or not charged, those who must pay the toll because they have no other viable option by which to make their journey, or those who change to a less convenient route or mode of travel in order to avoid the toll (King, Manville and Shoup 2008, 361). This group can also include drivers who use other nearby highways that remain toll free who experience additional congestion (Small 1992, 363).

5.3.4.2 Identifying Stakeholders

While decision makers will be aware of the situations facing potential winners and losers like those previously mentioned, individuals who are concerned about a road pricing scheme, also known as stakeholders, are not going to fall into clearly identified groups of winners and losers. Instead, these stakeholders will be distributed across a variety of different interest groups, and decision makers need to ensure that the interests of these groups are accounted for in the planning and implementation processes. Decision makers may be able to predict how a certain group of stakeholders will react to a road pricing proposal based on the assumed interests of that particular group, and these assumptions are laid out in table 5.7. However, it is important for decision makers not just to make assumptions about how stakeholders might react to a proposal when in the planning stages of a project. For example, the Ontario provincial government assumed that the Ontario Trucking Association, the Canadian Automobile Association, and the Ontario Motor Coach association would oppose tolling on Highway 407 (Mylvaganam and Borins 2004, 23). It turned out, however, that these groups saw tolls as a way to finish the highway's construction earlier, and were supportive of tolling so long as the tolls were removed once the highway was fully paid for (Mylvaganam and Borins 2004, 23). In order to ensure the successful implementation of road pricing, decision makers should identify all the stakeholders and confirm that any assumptions made about that group's reaction to a proposal are in fact correct. Examples of these stakeholder groups and the assumptions that could be made about them based on previous experience are given in table 5.7.

Table 5.7: Predicting Interest Groups' Stances on Road Pricing

Interest Group	Likely Stance	Rationale
Car Drivers/Automobile Associations	Against	Advocate for reducing congestion while minimizing user fees and tolls
Business Groups	In Favor	Road pricing can guarantee trip times but they are opposed to disproportionally high tolls for commercial vehicles
Trucking Organizations	In Favor	Road pricing can guarantee trip times but they are opposed to disproportionally high tolls for commercial vehicles
Businesses Within Proposed Cordon	Against	Fearful of losing business due to reduced traffic volumes within the cordon
Environmental Groups/Slow-Growth Advocates	Mixed	Generally opposed to new highways due to environmental concerns, in favor of pricing on existing highways to promote carpooling and public transportation use
Government Officials	In Favor	Often support major public works, even if such projects are not truly necessary, the opinions of government officials are often viewed with skepticism by other interest groups as a result
Taxi Drivers	In Favor	Pricing guarantees trip times and lowers congestion levels, but taxi drivers will oppose pricing if it hurts their ability to earn revenues

Sources: Data adapted from Lindsey 2007; Small 1992; Ungemah and Collier 2007.

5.3.4.3 Preconceived Notions can be Challenged

Road pricing can be initially opposed for several reasons. Some reasons that tolls are opposed by some drivers are that tolls are seen as being a tax on something that had previously been free, tolls provide a higher level of service to those who can afford to pay them, and that private firms in public-private partnerships charge the tolls with the sole objective of turning a profit while operating the roadway (Ungemah and Collier 2007, 69). Yet after road pricing schemes are implemented, survey results often indicate that many drivers view the pricing scheme in a favorable way. The HOT lanes on Interstate 15 San Diego opened in 1996. In a survey of 1,500 drivers between the fall of 1997 and 2000, 89 percent believed that the HOT lanes were "a success" and 77 percent of respondents thought the HOT lanes were "fair" to both HOT lane and general purpose lane users (Ungemah and Collier 2007, 67). Survey results in 2001 were similar, with at least 60 percent of respondents in all income groups approving of the Interstate 15 road pricing scheme (Ungemah and Collier 2007, 67). The question that must be answered is how can decision makers overcome initial preconceived notions and skepticism and implement a successful project.

One key is that travelers are unlikely to understand the abstract, technical jargon that economists, transportation planners, and politicians typically use when discussing road pricing. If decision makers want a road pricing concept to be embraced by the public at large, they must understand how the system will work, how the toll revenue will be used, and how the system will directly impact their travel patterns, if at all (U.S. Department of Transportation 1996, 16). Decision makers need to explain the benefits of adopting road pricing, such as those in section 5.3.4.1, to the public, although decision makers should be honest and straightforward about any possible negative impacts that may occur as well (Ungemah and Collier 2007, 69-70). All the financing sources and revenue uses, including ways that the revenues cannot be used, should be explained as well. If there is a public-private partnership, the way in which the revenues are used by all the partners should allay concerns that the private partner might set toll rates to maximize profit as opposed to serving the interest of the traveling public. This type of information can be distributed through task forces, open houses, surveys, and educational materials. There should also be a system by which concerned parties can voice their concerns, and decision makers should attempt to modify the proposal around these suggestions to maximize public acceptability.

Finally, the most publicly acceptable road pricing proposals are those that affect very few people. The world's three most well known congestion pricing schemes in London, Singapore, and Stockholm are designed so that the private vehicle driving minority pays a toll where the revenues are used to fund public transportation, which the majority of commuters are using in the first place (King, Manville and Shoup 2008, 363). This sort of situation is hard to come across in the United States where nationally, only 12 percent of the population is non-drivers (Lee 2008, 219). However, if the overwhelming majority of travelers are not going to pay the toll and their trip times take no additional time after the road pricing scheme is implemented in a worst-case scenario, the road pricing proposal is likely to meet little opposition from the public.

5.3.4.4 Case Study: Interstate 394 HOT Lanes

In May 2005, a HOT lane opened on Interstate 394 in Minnesota (Buckeye and Munnich 2006, 80). While nearly all stakeholders regard the Interstate 394 HOT lane's implementation as being successful and acceptable, two previous attempts to bring road pricing to Minnesota failed due to well organized public opposition (Ungemah and Collier 2007, 68). As a result, decision makers took deliberate steps to avoid having another project fail because of public opposition.

Figure 5.3: Interstate 394 HOT Lane Timeline

1992: HOV-2 facility opens
2001: Value Pricing Advisory Task Force Formed
2002-2003: Value Pricing Advisory Task Force carries out research, education, and communication strategies
2003: Legislation passed supporting conversion of existing HOV lane to HOT lane
September 2003-October 2004: I-394 Express Lane Community Task Force meets monthly
December 2003: Public-Private Partnership to construct I-394 HOT lane established
February 2004-March 2004: Focus groups meet
May 2005: HOT lane opens

Source: Data adapted from Buckeye and Munnich 2006.

The Interstate 394 HOT lane was originally a HOV-2 facility deemed to be underutilized immediately following its opening in 1992 (Buckeye and Munnich 2006, 80). However, the Value Pricing Advisory Task Force, a panel of politicians as well as business, environmental, and transportation association leaders set up to "explore appropriate and feasible value pricing options in Minnesota", concluded that while the HOV lanes were underutilized, converting the HOV lanes to general purpose lanes was not feasible, nor was there enough funding available to expand the existing highway (Buckeye and Munnich 2006, 81-82). Additionally, surveys as early as 1998 showed that 53 percent of Minnesota drivers were willing to use a HOT lane, 46 percent would pay up to 50 cents for 20 minutes in time savings, and that 36 percent would join a carpool to be able to use the HOT lanes for free (Kwon and Kelen 1998). A later survey conducted by the panel indicated that 55 percent of Minnesotans were willing to pay tolls to avoid congestion and 52 percent were interested in increasing the gas tax to pay for transportation improvements (Buckeye and Munnich 2006, 81). However, the sample sizes and methodologies for these surveys are unknown. In response to these findings, the Minnesota legislature authorized the implementation of

HOT lanes within the state in 2003; the legislation required that revenues had to be used for capital improvements and improving bus services in the same corridor as the HOT lanes were constructed (Buckeye and Munnich 2006, 83).

However, despite the promising survey results, politicians were fearful that this road pricing attempt would fail to be implemented, just like the previous two attempts. Therefore, a decision was made to establish the 22-person I-394 Express Lane Community Task Force, consisting of a politician and citizen from each city in the Interstate 394 corridor, some state legislatures, as well as representatives from advocacy groups and public agencies such as the American Automobile Association, Minnesota Trucking Association, Metro Transit, and the Minnesota Department of Transportation (Buckeye and Munnich 2006, 83). The purpose of the task force was to create links between the decision makers within the Minnesota Department of Transportation (Mn/DOT), politicians, and citizens so that the final proposal would be acceptable to all stakeholders. Task force members were briefed on the theoretical concept behind HOT lanes, and they also visited the existing California State Route 91 and Interstate 15 HOT lane projects to observe how HOT lanes work firsthand (Buckeye and Munnich 2006, 83). Additional surveys were conducted with focus groups that were observed by task force members to truly gauge the interest of potential HOT lane users and to learn what concerns these potential users might have to avoid “launch-related issues” (Buckeye and Munnich 2006, 84). A series of open houses was held that were open to all citizens in the Interstate 394 corridor (Buckeye and Munnich 2006, 85). The purpose of these events was to create a forum where concerns could be heard and travelers could be educated about how the HOT lanes would work (Buckeye and Munnich 2006, 85). Finally, task force members also received frequent updates on the project's progress from the Mn/DOT project managers throughout the planning process (Buckeye and Munnich 2006, 83).

Although the Interstate 394 HOT lane proposal had critics and not everyone who attended the meetings was in fact supportive of the project, there was no formally organized opposition against the HOT lanes, likely due to the inclusion of all stakeholders through the I-394 Express Lane Community Task Force, focus groups, surveys, and public outreach during the planning, design, and implementation phases of the project (Buckeye and Munnich 2006, 85).

5.3.5 Equity Concerns

Allaying equity concerns is often a large component of ensuring that formal opposition to a road pricing scheme does not materialize. While public acceptance may be the largest hurdle that decision makers need to overcome when implementing a road pricing scheme, as a subset of gaining public acceptance, assuring all stakeholders that a proposal is in fact equitable can be the biggest challenge (Ungemah 2007, 13). Ironically, when very few people had automobiles yet roads were publicly financed, people thought that was unjust since so few people could actually make use of the publicly funded road (Ungemah 2007, 14). Today, nearly every adult in the United States drives a car on a publicly financed road at some point during his or her lifetime, and roads and transportation services are seen by many as a public good to which everyone is entitled equal access (Ungemah 2007, 14). Therefore, the idea of tolling roads and potentially making them inaccessible to certain travelers is troubling to some people.

Table 5.8: Policy Foundation of Equity Analysis

Policy	Action
Title VI of the Civil Rights Act of 1964	"No person in the United States shall…be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."
National Environmental Policy Act of 1969	Required an analysis of environmental impacts beyond the infrastructure itself for major transportation projects
Federal Aid Highway Act of 1970	Ensured that transportation facilities be approved "in the best overall public interest" with efforts to eliminate or minimize the effects on community cohesion, employment effects, and the displacement of people
Civil Rights Restoration Act of 1987	Identified the extent to which Title VI applied to include all federal-aid recipients and contractors, regardless of whether the act in question was federally funded or not
Executive Order 12898 of 1994	Established the precedent that environmental justice be extended to low-income and minority populations and to avoid "disproportionately high and adverse" effects
U.S. Department of Transportation implementation actions	Provided requirements and guidance for transportation agencies and professionals in incorporating environmental justice principles

Source: Data adapted from Ungemah 2007, 13.

5.3.5.1 Defining Inequity in Transportation

The legislative basis for providing equity in transportation access in the United States is contained within several pieces of legislation, outlined in table 5.8 (Ungemah 2007, 13). When synthesized, these legislative acts direct planners "to avoid, minimize, or mitigate disproportionately high and adverse…effects on populations and low income populations, to ensure the full and fair participation by all potentially affected communities in the transportation decision-making process, and to prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority populations and low-income populations" (Ungemah 2007, 13). These are also referred to as the principles of "environmental justice" (Ungemah 2007, 13). Mobility and accessibility are usually the measures by which transportation equity are gauged (Rajé 2003, 323). Often, those with limited mobility and accessibility are clustered in areas with poor transportation options, or they are scattered across an area in such a way that long commutes are unavoidable (Rajé 2003, 323). However, equality needs to be considered in other ways as well. For example, if a project is beneficial to those below the poverty line but detrimental to those just above the poverty line, even though the project may be environmentally just based on the previously stated criteria, it is not necessarily equal to everyone involved (Ungemah 2007, 14).

These broad definitions of transportation equity provide a useful foundation for how road pricing might be unequal, but putting these broad definitions into a framework that relates directly to transportation and road pricing in particular would be less abstract and more relevant to the discussion. Issues with equity in transportation arise when some communities are impacted positively following the implementation of road pricing with regards to accessibility, trip times, and congestion relief whereas other communities are impacted negatively or experience far fewer positive impacts, when some communities pay disproportionately high taxes and user fees relative to the amount of service that community receives, or when some communities are underrepresented or not represented when the public is invited to provide input to the planning of a project (Carins, Greig, and Wachs 2003, 2). Put another way, if too many travelers in a community would be considered "losers" because of road pricing, while many travelers in another community would be “winners”, a plan might be inequitable to that first community. However, there are steps that can be taken to mitigate potential inequalities, should road pricing in fact be inequitable.

5.3.5.2 The Truth about Inequity and Road Pricing

Unfortunately, there is no good way to evaluate the equity impacts of road pricing because it is virtually impossible to create an accurate model that would show the equity impacts that would result from implementing road pricing (Eliasson and Mattsson 2006, 605). Those who have tried answering whether road pricing would benefit the poor or rich, and if it would adversely impact one of those groups in the process, have reached different results depending upon the specific research methods used and assumptions made over the course of the study (Eliasson and Mattsson 2006, 604). However, as road pricing is implemented in various locations throughout the United States, surveys are beginning to create a clearer picture as to whether road pricing poses legitimate equity concerns or not.

In surveys administered by the Federal Highway Administration’s Congestion Pricing Pilot Program, Caltrans, and California Polytechnic State University between late 1995 and early 1997, the idea of having variable tolls on California State Route 91 had an “approval rating” of 45 percent, with the primary objection being that the tolls were “unfair” (Ungemah and Collier 2007, 67). Additionally, two lawsuits were filed against the state to prevent the HOT lane proposal from going forward due to equity concerns (Ungemah and Collier 2007, 67). However, once the HOT lanes were constructed and opened, survey data indicated that the HOT lanes are not “Lexus Lanes” and that they are approved of and used by drivers in all income groups. A 1999 survey of nearly 2500 highway users in the Route 91 corridor found that low-income drivers approved of and used the Route 91 HOT lanes just as much as higher income drivers, including 50 percent of travelers with incomes of less than $25,000 (Sullivan 2000, 115-120; Sullivan 2000, 126). While higher income commuters are twice as likely as commuters in the lowest income group to be frequent HOT lane users and half as likely to be non-users, 18 percent of drivers with incomes of less than $40,000 use the HOT lane frequently (Sullivan 1998; Dahlgren 2001, 12). Additionally, only half of the Route 91 HOT lane users make use of the HOT lane more than once a week (Sullivan 1998; Dahlgren 2001, 12). However, it is important to note that the "typical commuter" in the Route 91 corridor is "a professional or manager from a relatively high income, multiple vehicle...household", so a degree of caution should be taken when using Route 91 to establish best practices for future road pricing projects (Sullivan 1998).

An analysis of potential equity issues on the Interstate 15 HOT lanes near San Diego yields results similar to those obtained for California State Route 91. There were two phases to the Interstate 15 HOT lane implementation. During the first phase from December 1996 until March 1998, SOV drivers purchased a pass that granted them unlimited access to the HOT lane, but only a certain number of passes were available for sale (Brownstone et al. 2002). In the second phase, which is currently ongoing, SOV drivers purchase a transponder connected to an account from which tolls are deducted; the study of equity issues with regard to Interstate 15 will be for this phase only (Brownstone et al. 2002). During both phases, carpools use the HOT lanes for free (Brownstone et al. 2002). Surveys taken between the fall of 1997 and the winter of 2000 found that 77 percent of drivers perceived the HOT lanes as being "fair" to both HOT lane users and general purpose lane users (Ungemah and Collier 2007, 67). In 2001, another survey was taken as part of a larger study to determine whether the HOT lane facility should be expanded. This survey found that sixty percent of respondents approved of the HOT lanes with support coming from all income groups, though higher income groups were more likely to be supportive (Ungemah and Collier 2007, 67). Additionally, while solo drivers who make more than $100,000 annually or who have post-college education are more likely to use the HOT lanes than those with less income or education, 70 percent of low income drivers support having the HOT lane as an option available to them for when they need it (Brownstone et al. 2002; U.S. Department of Transportation 2006, 9).

Finally, it is important to consider how feasible it is for travelers to change their schedules to avoid congestion or tolls. Surveys show that the ability to modify one's trip time are dependent on a number of factors, including travel time, travel costs, marital status, family obligations, income, occupation, and work schedule flexibility (Saleh and Farrell 2005, 774). Full time employees and students tend to be the most unwilling to change their schedules, whereas retirees, unemployed persons, and part time employees have the most schedule flexibility (Kockelman and Kalmanje 2004). While some people are able or willing to change their schedules to avoid paying charges as a result of road pricing, it is important to realize it may be unfair to charge a toll if many people are truly unable to do anything reasonable to avoid such charges.

In summary, if a driver is able to afford to buy and use a car, the additional cost of using HOT lanes on occasion is relatively small (Dahlgren 2001, 11). While lower income drivers may use HOT lanes less often than those who make more money, those drivers will use HOT lanes in circumstances where the value of their time is greater than that of the toll (Dahlgren 2001, 11). An example of when this might occur is if a driver is running late to pick up his or her child from daycare, if the highway is congested and the HOT lane toll is less than the daycare's late fees, the driver will likely opt to use the HOT lane (U.S. Department of Transportation 2006, 9). Additionally, those who do use HOT lanes rarely use them more than once a week, and many high income drivers never use them at all (Dahlgren 2001, 12; Sullivan 1998). However, some travelers will be unable to change their schedules to avoid tolls or congestion under any circumstance, due to one of potentially many constraints. While the data by which these conclusions is limited and being expanded as more road pricing schemes are implemented throughout the world, it appears as if equity concerns, while legitimate, are not nearly as serious as many initially think.

5.3.5.3 Allaying Equity Concerns

Although equity concerns may not be as pressing in actuality as people may initially think, since public acceptability is a major key to the successful implementation of a road pricing proposal, the public must be assured that the proposal is fair and just to all users. There are several things that can be done to accomplish this. One way is to compensate those who are severely impacted in a negative way by road pricing for the inconveniences that road pricing creates. Revenues can be designated for funding public transportation projects, under the assumption that improved public transportation options will benefit lower income travelers (Lindsey 2007, 16). Vickrey actually encourages this, saying that adequate funding for and giving prioritization to public transportation is the only way to make it a viable alternative to driving (Vickrey 1994b, 315). For the same reason, HOVs should be allowed to use HOT lanes at a discounted rate or for free; if HOVs are required to pay the same toll as SOVs, there is little to no incentive to carpool. An example of where toll revenues are dedicated to public transportation improvements is Interstate 15 in San Diego, where one-half of the revenues are used for that purpose (U.S. Department of Transportation 2006, 6).

Another option is to use credit-based congestion pricing (CBCP) instead of charging tolls directly to motorists. CBCP is “a revenue-neutral policy where road tolls are based on the negative externalities associated with driving under congested conditions” (Kockelman and Kalmanje 2004). Under such a system, those who drive the most or create the most congestion pay to subsidize others (Kockelman and Kalmanje 2004). If CBCP were to be implemented, each driver would receive an allowance and no out of pocket fees would be incurred until that allowance was exceeded (Kockelman and Kalmanje 2004). Drivers who do not use up their limit for a given month could receive a cash refund or have the unused credits roll over to the next month for future use (Kockelman and Kalmanje 2004). CBCP has not been implemented anywhere in the United States to date, although residents in Austin, TX were surveyed to gauge receptiveness to the idea. There were concerns about how such a system would be implemented, and those with inflexible schedules tended to be opposed to the idea since it was more likely they would use up their allowances and have to pay (Kockelman and Kalmanje 2004). It is important to note that fifty-six percent of respondents believed that the fairness of CBCP was “a pressing issue”, but based on experiences thus far, it is reasonable to assume that once a community became more familiar with how CBCP would work, concerns about fairness and difficulties in implementing the system would be mitigated (Kockelman and Kalmanje 2004).

Maintaining a parallel, toll free route to the road that is being tolled is recommended by many academics. This ensures that anyone who is unwilling or unable to pay a toll can still reach his or her destination. HOT lanes are preferable to tolling an entire highway for the same reason because any driver who does not wish to pay the toll associated with the HOT lane does not have to do so, although he or she may be subject to severe congestion as a result (Lindsey 2007, 19). In the case of a cordon, a “free route” can be designated so that through traffic need not take a roundabout route around an entire cordon, assuming the cordon is large enough to necessitate such an arrangement (Vickrey 1994b, 316). This was done in London when the Western Extension to the original LCCS was implemented (Santos 2008, 172-173).

Finally, exemptions and discounts can be given to travelers who would be unfairly affected by road pricing. Although Vickrey believed that exemptions from paying tolls should not be given under any circumstance and that even emergency vehicles should be subject to tolling, life cannot be governed solely by the rules of economics (Vickrey 1968, 117). In London, residents within the LCCS, as well as some residents within a certain distance of the LCCS Western Extension, receive a 90 percent discount on the congestion charge, and motorcycles, emergency vehicles, public buses, and taxis are among the vehicles that do not pay any toll (Santos 2008, 161). These types of vehicles should always receive significant discounts or exemptions because it is generally impossible for them to change their route or schedule in a reasonable manner to be able to avoid congestion.

Table 5.9: Equity Mitigation Options

- Provide compensation to those who are severely impacted by road pricing schemes
  - Appropriate revenues to public transportation projects
  - Credit-based congestion pricing (CBCP)
- Maintain parallel free route for HOT lanes
- Maintain free route across cordons if driving around is not feasible
- Provide exemptions or discounts to those who cannot afford or avoid toll payments

Source: Data adapted from Ungemah 2007, 13.

5.4 Recapping the Implementation Strategies

As one can see, the issues surrounding road pricing, as well as the potential challenges to implementing a successful scheme, are complex. Skeptics have raised their concerns since Vickrey first published his theories over fifty years ago, ranging from semantics debates over whether the theory was proposing a toll or a tax, to whether road pricing is equitable to all stakeholders who may be affected by a road pricing scheme. As actual road pricing projects have been implemented in the United States in recent years, decision makers can now turn to actual case studies and data while planning new road pricing schemes. However, road pricing is not yet ready to be implemented on a wide scale throughout the United States. The next chapter discusses what types of pilots should be run before road pricing is universally embraced as a strategy to raise revenue, manage congestion, or both.

CHAPTER 6: ROAD PRICING IN THE FUTURE: NEXT STEPS

Forty-three years after Clifford Sharp raised issues with the proposals laid out in the Smead Report and encouraged additional study of road pricing, we find ourselves in a similar place. Vickrey's original theories are almost ready to be considered sound transportation planning policy in the United States. There is enough conclusive data from existing road pricing applications to show that HOV lanes are usually underutilized and that equity concerns with regard to HOT lanes do not necessarily play out as feared. There is also a demand for HOT lanes, as evidenced by SOV drivers in Northern Virginia who value their time so highly, they are willing to use the HOV lanes and run the risk of $1,000 fines, doubled insurance premiums, and losing their drivers' licenses despite not complying with the occupancy restrictions (Weiss 2009a). However, the federal government should fund additional pilot programs to test certain conditions before recommending to local governments that they set up road pricing schemes to solve congestion issues and to raise revenue.

6.1 Things to Test

While it is true that low income drivers use HOT lanes as often, or even more often in some cases, than higher income drivers, most of the United States' existing HOT lane facilities, such as California State Route 91, are in areas where the travelers have very high incomes (Sullivan 1998). Therefore, the chances of equity impacts affecting a large number of low income drivers are lower than if the income in the HOT lane corridor was average. The government should fund HOT lane pilot projects for several highway corridors where the average traveler has a lower income level than the drivers in the corridors where HOT lane facilities already exist to see if equity concerns truly are not as serious an issue as road pricing opponents claim.

Another hurdle for widespread road pricing in the United States is that Americans are very dependent upon their cars, and that urban areas in the United States are not laid out the same way that they are in Europe and Asia where road pricing is more widely implemented. HOT lanes have a toll free alternative in the general purpose lanes running alongside the tolled facility, and American city centers are not necessarily the most congested part of an urban transportation network (Rye and Ison 2008, 290). This is why HOT lanes are usually the road pricing method of choice in the United States, as opposed to the cordons more frequently found in Europe; there are so few non-drivers in the United States a cordon would negatively affect most drivers in nearly any city it is attempted in (Lee 2008, 219). However, a cordon toll should be attempted in New York City, one of few if not the only place where such a plan could work. While about 40 percent of travel in New York's central business district is by car compared to less than 20 percent of London commuters, the fact that Manhattan is an island and that New York has one of the most extensive public transportation systems in the United States makes it a perfect candidate for a cordon pilot test. Additionally, tolling all of the remaining toll free bridges into Manhattan is already on the table as a way to avert public transit cuts (Neuman 2009). Discounts and exemptions could be provided for residents of Manhattan, as well as those who live on Long Island and cannot access their homes without paying a toll. Such a road pricing application may not be able to work anywhere else aside from New York City, but it would still be worthwhile to evaluate its feasibility.

A pilot should also be developed to test a CBCP scheme, such as the one discussed in Kara Kockelman and Sukumar Kalmanje's 2004 *Credit-Based Congestion Pricing: A Policy Proposal and the Public's Response*. Developing a workable pilot may be difficult since the allowance rate should be based off an entire society's driving patterns, so the results of a pilot where only a certain number of volunteers participate may not be conclusive or useful in adopting subsequent policies. However, an attempt should be made to design and run such a pilot.

Finally, a pilot project that tests the feasibility of mileage based charging to replace the gas tax, along the lines suggested by Transportation Secretary Ray LaHood, should be undertaken. Such a test violates the best practice of retaining toll free options to ensure equality to all travelers, however, since the gas tax is not an effective way to raise revenue for either road or public transportation funding, all other options should be considered seriously. One way to do this could be to require all cars to have an electronic identifier or transponder that would be connected to the car's odometer and would synchronize with the gas pump when the car arrived at a gas station to be refueled, at which time the appropriate tax could be charged. The identifier could also be programmed to account for differing gas mileages between different types of cars, so a hybrid and SUV could be charged a tax that correlates to the differences in each car's fuel efficiency. Implementing this type of proposal would involve overcoming equity and privacy concerns, among other potential issues. However, the need to identify feasible ways to finance transportation projects is urgent. The worst thing that can happen is that the pilot test will fail or the concept will be rejected in the arena of public opinion, but the only way to find out if this is the case is by running such a test.

Table 6.1: Concepts that need Further Testing

Proposal	**Rationale**
HOT Lane Pilot in Low Income Corridor	HOT lanes have not been proven to be inequitable to lower income travelers, however, most of the corridors where the concept has been tested have high average incomes, suggesting that there are fewer low-income drivers who could potentially use the corridor and be surveyed
Cordon Toll Pilot	Although unsuitable for most parts of the United States, cordon tolls may be feasible in places such as Manhattan, and therefore the concept should be tested to determine its feasibility in the instances where it might be able to be successfully applied
Credit-Based Congestion Pricing (CBCP) Pilot	Surveys indicate this type of congestion pricing may be accepted easily by public, so it would be beneficial to try developing a test to verify this survey finding and determine the feasibility of CBCP
Vehicle Mileage Based Tax Pilot	Gas taxes do not correlate to actual vehicle use and are not an effective way to charge people for their road usage, so all proposals to develop a method by which drivers are charged for their actual mileage and fuel consumption should be considered

Sources: Data adapted from Sullivan 1998; Lee 2008, 219; Rye and Ison 2008, 290; Kockelman and Kalmanje 2004.

6.2 Maintaining Standards

Many best practices are mentioned at various points throughout this paper, and they are also outlined in the appendix. These best practices have been established as such by a variety of academics and through actual experience on the existing road pricing schemes within the United States. They cover a wide range of topics, pertaining to nearly every aspect of a road pricing proposal. The most important practice is that decision makers must decide if they want to prioritize welfare maximization or revenue maximization, and then do their best to make all subsequent decisions in accordance with this first decision (Holguín-Veras, Cetin, and Xia 2006, 854). Public-private partnerships, if pursued, must be designed to protect the interests of the traveling public and if too many concessions need to be made to the private operator in order to make a deal, the partnership may not be worthwhile (Mylvaganam and Borins 2004).

Dynamic toll rates are more likely to change drivers' behavior than predetermined schedules, and off peak discounts will encourage travel at times when the roads are not congested (Brownstone et al. 2002; Vickrey 1994b, 307). Electronic toll collection is the most efficient and least expensive way to collect the tolls. However, decision makers should use collection systems that also allow for drivers without transponders to use the facility, and for a single transponder to work on as many facilities as possible (Vickrey 1994b, 314; Mylvaganam and Borins 2004, 41; Levinson 2002, 187). There are a variety of ways in which revenues can be used, including funding initial construction or expansion of the tolled facility, other road construction, or public transportation projects in the same corridor (Mylvaganam and Borins 2004, 27; Lindsey 2007, 14; Small 1992, 369). However, making sure the traveling public knows how the revenues are used is more important than choosing their use.

The biggest challenge in successfully implementing road pricing is ensuring that a proposed scheme is acceptable to and understood by the public (Ungemah 2007, 13). Decision makers must identify all key stakeholders who will potentially be affected by a proposal and include them in the planning and implementation phases of the project (Lindsey 2007, 15; Buckeye and Munnich 2006; Mylvaganam and Borins 2004, 23; Ungemah and Collier 2007, 69-70; Ungemah 2007, 14). Individual travelers also tend to be supportive of pricing when they will not be charged under a proposed scheme (Lee 2008, 219). Part of gaining public acceptability is addressing equity concerns, even if research indicates that in practice, road pricing is not inequitable despite people's fears to the contrary (Ungemah 2007, 13). Equity concerns can be addressed by designating some or all of the toll revenues for public transportation that lower income travelers are more likely to use, by maintaining a toll free alternate route for those who do not wish or cannot afford to pay the toll, or by providing discounts or exemptions to residents or workers who would be adversely affected by the scheme (Lindsey 2007, 16; Vickrey 1968, 117; Santos 2008, 161).

It is important for decision makers to remember that no two projects are alike, and that these best practices merely serve as a guide for successful implementation. Some best practices may not apply to or be appropriate for certain proposals, while other practices will need to be sacrificed in the interest of gaining public acceptability or in dealing with the political realities of a situation. However, these practices should be maintained on all future projects, including the next round of pilot programs recommended within section 6.1.

6.3 Final Thoughts

While the recommendation that the federal, state, and local government identify additional locations where pilot programs could be implemented for yet another round of testing may seem like an attempt to put road pricing policy formulation into an endless cycle of tests and pilots that will never be completed, in order for road pricing to be successful, decision makers need to get it right, and they need to get it right the first time. Even though road pricing is widespread in Europe and Asia, urban areas in those locations have a different layout and organizational structure than American cities, and the automobile is not the primary mode of transportation for as many people as it is in the United States (Rye and Ison 2008, 290; Lee 2008, 219). It is also important to note that the United States has often looked to other countries for transportation innovation ideas. The IHS is modeled after Germany's *autobahnen*, and the Acela Express high speed train is modeled after a variety of European trains. Additional pilots will allow decision makers in this country the opportunity to appropriately modify what has worked elsewhere for the United States' unique needs. When these pilots are complete, the resulting policy can result in the United States' road pricing applications being the models that international cities attempt to emulate in the future. However, like a driver making a long road trip, it is important to pull over to the side of the road every so often and ensure that all is in order before proceeding onward. It is time for American road pricing policy to find a "rest stop" and evaluate current conditions, but before too long, this policy will reach its "destination" and become well established.

APPENDIX: ESTABLISHED BEST PRACTICES FOR FUTURE ROAD PRICING SCHEMES IN THE UNITED STATES

This appendix lists the established best practices for future road pricing schemes in the United States. All of these best practices appear throughout my paper and they are listed here in bullet point format for easy reference. Most of the practices listed here were either cited in the academic research I used as a foundation for my own writing, or they were critical to the success of at least one of the case studies I examined in the course of my research. A few of the practices were established to directly counter academics who made proposals that simply cannot work or have not been proven to work, or because they were not heeded and an attempted pricing scheme implementation failed as a result.

It bears repeating that these established best practices are merely recommendations and not strict guidelines. Some of these practices are easier to follow in some circumstances than others. Decision makers can and should strive to follow these practices wherever and whenever possible to ensure successful implementation of a scheme, but decision makers must also recognize that various variables, such as politics, available technology, and the necessity of public support, may require some practices to be partially or wholly compromised to achieve a scheme's desired result.

- Choosing a Road Pricing Scheme
    - Decision makers should decide if their goal is to maximize welfare, maximize revenue, or a combination thereof, and make all subsequent decisions in accordance with the scheme's goals (Holguín-Veras, Cetin, and Xia 2006, 854)

- If welfare maximization is the chosen goal, an accurate estimate must be made for how much travelers value their time (Holguín-Veras, Cetin, and Xia 2006)
- Build HOT lanes as an expansion of roadways that are at or over capacity if the goal is to expand the road while retaining an incentive to carpool (Dahlgren 2001, 6)
- If delays are minimal, a general purpose lane can provide extra capacity and reduce congestion just as effectively as a HOV lane or HOT lane (Dahlgren 2001, 13)
- HOV lanes and HOT lanes should not be constructed if there are not many potential users for such a lane (Dahlgren 2001, 8)

- Financing
  - When establishing public-private partnerships, the interests of the traveling public must be protected and these interests should not be sacrificed for the purpose of establishing such a partnership (Mylvaganam and Borins 2004)
  - If a highway is to be leased to a private operator, an ideal lease length is between 20 and 30 years, with an acceptable length being between 10 and 50 years (Mylvaganam and Borins 2004, 87)
- Setting Toll Rates
  - Toll rates should change gradually to avoid having drivers looking to avoid the higher toll rate creating a new peak period (Vickrey 1994a, 279; Dahlgren 2001, 7)

- Dynamic pricing is preferable to set schedules because rates will better reflect actual conditions as opposed to predictions (Victoria Transport Policy Institute 1992)
- Truckers and business organizations will not support schemes with disproportionately high tolls for commercial vehicles (Small 1992, 363)
- Use intelligent transportation systems to inform drivers of toll rate prior to the point at which they must pay the toll so that they may choose a toll free route if they prefer to do so (Vickrey 1994b, 312)

- Toll Collection
  - Devise a system by which vehicles without a transponder can still use a tolled facility, such as photographing license plates (Vickrey 1994b, 314; Mylvaganam and Borins 2004, 41)
  - It is appropriate to apply a surcharge to tolls for drivers who do not use the preferred toll collection method in order to cover for additional toll collection costs that may be incurred as a result (407 ETR)
  - Decision makers should attempt to develop compatible transponders to facilitate travelers, especially commercial vehicles and buses, that are likely to operate in different regions of the country (Levinson 2002, 187)
- Revenue Uses
  - Reduce gas taxes and vehicle registration fees if road pricing is able to be charged in a way that correlates with actual distance traveled (Vickrey 1968, 111)

- Although there is a risk in designating revenues from road pricing for a specific purpose in advance, designating a specific purpose for revenue use is useful in gaining public support for a road pricing scheme (Lindsey 2007, 14)
- The most successful road pricing schemes are designed so that a private vehicle driving minority subsidizes public transportation riding majority (Kockelman and Kalmanje 2004)

- Physical Design
  - Facilities should have at least two lanes or else traffic is limited to the speed of the slowest moving car on the facility (Kwon and Varaiya 2007, 105)
  - Facilities should be designed so that all vehicles, including trucks, can use them (Kawamura 2003)
- Gaining Public Acceptability
  - Identify potential stakeholders and make sure they are included throughout the planning and implementation process (Buckeye and Munnich 2006, 83-85; Lindsey 2007; Small 1992)
  - Decision makers may be able to make some assumptions about how a group of stakeholders might react to a road pricing proposal, but these assumptions should be verified (Ungemah and Collier 2007, 69-70; Mylvaganam and Borins 2004, 23)

- Use education initiatives and outreach programs to counter opposition to and explain benefits of road pricing proposals (Buckeye and Munnich 2006, 85)
- Public must understand how road pricing scheme will work, how toll revenues will be used, and how their travel patterns will be impacted (Ungemah 2007, 14)
- A system to receive public feedback should be established and publicized throughout the planning process (Buckeye and Munnich 2006, 83)
- Pricing schemes are easily accepted by those who will not be affected by them, such as in London where the LCCS is acceptable to most travelers since over 80 percent of them are not driving personal vehicles (Lee 2008, 19)
- Remove tolls once a project's construction costs have been paid for (Mylvaganam and Borins 2004, 27; Bae and Bassok 2008, 314)

- Equity Concerns
    - Road pricing proposals must be deemed as fair and just to all users in order to gain public acceptability (Ungemah 2007, 14)
    - Revenues can be designated for funding public transportation projects under the assumption that improved public transportation will largely benefit lower income travelers (Small 1992, 369; Lindsey 2007, 16)
    - Maintain a parallel, toll free route (for HOT lanes) or a toll free path (for cordons) so that drivers who are unwilling or unable to pay the toll can still reach their destinations (Rye and Ison 2008, 290)

- Toll free routes for cordons should cross the cordon itself if a route around the cordon would be too circuitous (Lindsey 2007, 19; Vickrey 1994b, 316)
- Provide exemptions and discounts to residents living within the cordon, emergency vehicles, and other groups who would be severely impacted if they did not receive such benefits (Santos 2008, 172-173)
- Consider who the “average” traveler in a corridor is, and if there are few low income travelers in a corridor, there are likely to be few equity impacts (Sullivan 1998)

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