A ROAD PRICING STRATEGY FOR GREATER VANCOUVER

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ABSTRACT

The traditional response of governments to the problem of traffic congestion has been to increase transport capacity. This policy focus has not been effective. Despite significant investment in highways, roads, and public transit, traffic conditions in most major cities continue to deteriorate. Furthermore, increased public awareness of the environmental effects of the automobile together with the fiscal reality facing all governments in Canada reduces the capacity for future road building projects. A new approach to urban transport policy is therefore required.

Road pricing has long been advocated by economists as a means of making more efficient use of the road network. Unlike traditional flat rate tolls, road pricing charges would vary based on prevailing traffic conditions. Charging motorists for road space during congested peak periods would induce some motorists to switch to alternate modes or to make their trips at less congested times.

Despite its economic rational, road pricing has yet to be implemented on a wide scale. Previous road pricing schemes have tended to focus on economic and technical issues to the exclusion of political concerns. In virtually all cases where road pricing has been proposed, political opposition has caused road pricing plans to be significantly scaled back or abandoned all together. If road pricing is to be implemented, future plans will have to address political as well as economic and technical issues.

This thesis examines the political and economic issues raised by road pricing. Using Greater Vancouver as a case study, the thesis seeks answers to the key design questions involved in implementing a road pricing system. The principle findings of this research are: (1) road pricing should be presented as a means of making better use of the region’s transportation system, not as a source of government revenue; (2) road pricing revenues should be used to improve transit, offset existing taxes, and promote high density housing along major transit corridors; (3) road pricing should be implemented on the Lions Gate Bridge as a demonstration project; and (4) road pricing measures should be integrated with transportation and land development policies.
# TABLE OF CONTENTS

**ABSTRACT** ........................................................................................................ ii

**TABLE OF CONTENTS** ......................................................................................... iii

**LIST OF FIGURES** ............................................................................................ vii

**LIST OF MAPS** ................................................................................................. viii

**LIST OF TABLES** ............................................................................................... ix

**ACKNOWLEDGEMENTS** .................................................................................... x

**CHAPTER 1: INTRODUCTION**

- **A:** INTRODUCTION .................................................................................. 1
- **B:** A DEFINITION OF ROAD PRICING ................................................... 2
- **C:** THE URBAN TRANSPORTATION PROBLEM .................................. 3
  - 1: Responses to the Urban Transportation Problem .............................. 3
- **D:** REASONS FOR RENEWED INTEREST IN ROAD PRICING ........... 4
  - 1: Failure of Traditional Policies .............................................................. 5
  - 2: Changing Political Attitudes ................................................................. 6
  - 3: Technological Improvements ............................................................... 7
- **E:** PURPOSE ............................................................................................... 7
- **F:** RELEVANCE OF THE THESIS .......................................................... 8
- **G:** SCOPE ................................................................................................... 8
- **H:** METHOD ............................................................................................... 8

**CHAPTER 2: THE ECONOMICS OF ROAD PRICING**

- **A:** INTRODUCTION .................................................................................. 10
- **B:** THE EXTERNAL COSTS OF ROAD TRAVEL .................................... 10
  - 1: Accident Externalities ......................................................................... 11
  - 2: Environmental Pollution ................................................................... 11
  - 3: External Road Damage Costs .............................................................. 12
  - 4: Congestion Costs .................................................................................. 13
- **C:** CONGESTION AND THE PUBLIC OWNERSHIP OF ROADS .......... 13
- **D:** AN ECONOMIC MODEL OF CONGESTION AND ROAD CHARGES .... 15
  - 1: A Pricing Rule for Road Transport .................................................... 19
  - 2: Road Investment Policy under Marginal Cost Pricing .................... 20
- **E:** ESTIMATES OF THE BENEFITS OF ROAD PRICING .................... 21
- **F:** CONCLUSION ....................................................................................... 22
CHAPTER 3: THE POLITICS OF ROAD PRICING

A: INTRODUCTION ............................................. 24
B: OBJECTIONS TO ROAD PRICING .......................... 26
   1: Equity ................................................. 26
   2: Scepticism Regarding the Effectiveness of Road Pricing .... 28
   3: Invasion of Privacy ..................................... 29
   4: Effects on the Economy .................................. 30
   5: Road Pricing as a Form of Taxation ....................... 31
C: DISTRIBUTIONAL CONSIDERATIONS AND POLITICAL ACCEPTABILITY ...... 31
   1: Tolling an Existing Road ................................ 32
      a. Winners and Losers ........................................ 32
      b. Is Road Pricing Regressive? ................................ 33
      c. Effects of the Comprehensiveness of the Charging System ... 34
      d. Congestion Levels and Political Acceptability ............ 34
      e. Winners, Losers, and Political Activism ................... 35
   2: Tolling a New Road ...................................... 36
D: INTEREST GROUPS AND STAKEHOLDERS IN THE ROAD PRICING DEBATE ...... 37
   1: Motoring Associations .................................... 37
   2: Transit Advocates and Riders .............................. 39
   3: Nonmotorists ............................................. 39
   4: Environmentalists ........................................ 40
   5: Business Interests ....................................... 41
   6: Taxicab and Trucking Industries ......................... 42
E: THE PROBLEMS AND OPPORTUNITIES OF HIGH TOLL REVENUES ............ 42
   1: Guiding Principles for the Use of Road Pricing Revenues ...... 44
F: MODELS FOR IMPLEMENTING ROAD PRICING .......................... 46
G: CONCLUSION ............................................... 49

CHAPTER 4: TRANSPORTATION IN GREATER VANCOUVER

A: INTRODUCTION ............................................. 51
B: GOVERNMENT STRUCTURE AND TRANSPORT PLANNING ...................... 52
   1: The Legal Context of Local Government in British Columbia .... 52
   2: Government in Greater Vancouver ............................. 53
   3: Provincial and Local Responsibilities for Transport ............ 56
      a. Private Road Transport .................................... 56
      b. Public Transportation ...................................... 57
   4: Responsibility for Land Use Control .......................... 58
C: THE TRANSPORTATION NETWORK IN GREATER VANCOUVER .................. 58
   1: Geographical Constraints .................................... 58
   2: The Existing Road and Highway Network ....................... 59
   3: Public Transit in the Region .................................. 61
D: POPULATION TRENDS AND TRAVEL PATTERNS .................................. 61
   1: Population Trends .......................................... 61
   2: Travel Volumes ............................................. 62
   3: Changes in Travel Patterns ................................... 62
   4: Trends in the Mode of Travel .................................. 64
# CHAPTER 5: A ROAD PRICING STRATEGY FOR GREATER VANCOUVER

## A: INTRODUCTION

## B: WHY ROAD PRICING?

1. The Failure of Current Policies
2. Road Pricing is More Effective than Other Policies
3. The Efficiency Between Land and Transport Prices

## C: DESIGN ISSUES FOR ROAD PRICING

1. The Objectives of Road Pricing
2. Comprehensiveness of the Charging System
3. The Use of Road Pricing Revenues

## D: IMPLEMENTATION ISSUES

1. Is a Regional Authority Necessary?
2. Implementing Road Pricing

## E: ROAD PRICING IN THE CONTEXT OF LAND USE AND TRANSPORTATION POLICY

1. Road Pricing and Land Use Policy
2. Road Pricing and Transportation Policy
   a. Road Building
   b. Public Transit and HOV Facilities
   c. Pedestrian and Bicycle Facilities

## F: CONCLUSION

---

# CHAPTER 6: CONCLUSION

## A: SUMMARY

## B: CLOSING COMMENTS

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# REFERENCES

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# APPENDIX 1: ELECTRONIC ROAD PRICING TECHNOLOGIES

## A: INTRODUCTION

## B: IN-VEHICLE UNITS

## C: PAYMENT AND ACCOUNTING SYSTEMS

## D: ROADSIDE COMMUNICATION TECHNOLOGIES

## E: VEHICLE DETECTION

## F: UNIQUE VEHICLE IDENTIFICATION TECHNOLOGIES

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# APPENDIX 2: ROAD PRICING CHARGING STRUCTURES

## A: INTRODUCTION

## B: POINT OR CORDON CHARGES

## C: DISTANCE-BASED CHARGES

## D: DURATION-BASED CHARGES
APPENDIX 3: ROAD PRICING EXPERIENCES IN OTHER COUNTRIES

A: SINGAPORE .................................................. 109
B: HONG KONG ................................................. 111
C: NORWAY ....................................................... 113
D: RANDSTAD REGION - THE NETHERLANDS ............... 115
E: OTHER NOTABLE ROAD PRICING EXPERIENCES ........... 117

1: London, England ............................................. 117
2: Cambridge, England ......................................... 118
3: United States ................................................ 118
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>The Relationship between Travel Time, Density, and Flow</td>
<td>16</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Optimal Congestion Toll and Welfare Loss</td>
<td>18</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Sub-regional Commuting Patterns 1985-92</td>
<td>63</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Morning Peak-Period Mode Share 1985-92</td>
<td>63</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Work Travel Characteristics 1985-92</td>
<td>63</td>
</tr>
</tbody>
</table>
# LIST OF MAPS

<table>
<thead>
<tr>
<th>Map 1:</th>
<th>Vancouver CMA</th>
<th>54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map 2:</td>
<td>Major Transportation Corridors</td>
<td>60</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1: Population and Employment in the Vancouver CMA ......... 55
Table 2: Public Perception of Transportation Problems ................. 66
Table 3: Public Reaction to Alternate Toll Options .................... 67
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A: INTRODUCTION

I will begin with the proposition that in no other major area are pricing practices so irrational, so out of date, and so conducive to waste as in urban transportation. Two aspects are particularly deficient: the absence of adequate peak-off differentials and the gross underpricing of some modes relative to others.

In nearly all other operations characterized by peak load problems, at least some attempt is made to differentiate between the rates charged for peak and for off-peak service. Where competition exists, this pattern is enforced by competition: resort hotels have off-season rates; theatres charge more on weekends and less for matinees. Telephone calls are cheaper at night ... But in transportation, such differentiation as exists is usually perverse. (Vickrey 1963, 452)

More than thirty years after Professor Vickrey's influential 1963 article Pricing in Urban and Suburban Transport, the pricing of urban transport, particularly private road transport, remains almost completely irrational. While some public transit systems charge higher fares during peak periods, the monetary cost of driving to the private motorist remains completely unresponsive to fluctuations in demand. Chapter 2 of this thesis illustrates that the lack of a price system to ration scarce road capacity during periods of peak demand results in excessive private road travel. The costs to society of this excess consumption are difficult to measure. However, considering the size of the urban transport sector and the high levels of traffic congestion found in many metropolitan areas, these costs are surely significant. Although traffic congestion and its concomitant costs are a necessary result of the human and economic interactions that define a city, road pricing can help to reduce congestion to a more efficient level.
B: A DEFINITION OF ROAD PRICING

Road pricing, road use pricing, road user pricing, and congestion pricing are all terms used in the literature to refer to time and place specific charges imposed on moving vehicles (May 1992, 314). Strictly speaking, congestion pricing is more restrictive than the other terms in that it implies that charges for use of the roadway would vary with congestion but not with other external costs of road use. In practice, as discussed in Chapter 2 of this thesis, congestion is the largest external cost of road use that cannot be internalized through existing instruments and hence the term congestion pricing is probably justified. Nonetheless, this thesis restricts the use of the term congestion pricing to circumstances where the road charge is based solely on congestion levels and when referencing the work of others who use the term. The remaining terms listed above are used interchangeably in the thesis.

A possible source of confusion surrounds the use of the word toll. A toll is defined as "a tax paid for some liberty or privilege" (Merriam-Webster Inc. 1986), and often refers to a charge for the use of a particular segment of roadway. Although tolls or toll roads have traditionally been associated with flat rate charges,\(^1\) there is nothing inherent in the term that restricts its use in this way. Where the term toll is used in this thesis with reference to road pricing or congestion levels, it should be understood that the toll will vary by time of day. Where the term is used in isolation, the principles or ideas under discussion apply equally to flat rate and time specific tolls and hence no distinction between the two is made.

\(^{1}\)A flat rate charge is uniform throughout the day and hence is unrelated to congestion or other time specific external costs.
C: THE URBAN TRANSPORTATION PROBLEM

In the absence of peak-period pricing, traffic congestion is the only mechanism by which scarce road space is rationed. Congestion arises whenever the demand for road space exceeds the available supply. Unlike the supply, which is constant throughout the day, the demand for road space exhibits a distinctively peaked nature. In most cities, the demand for road space far exceeds the supply during peak periods; nonetheless, the urban road network remains underutilized most of the time. Although it may often appear that urban transport infrastructure is undersupplied, if travel demand were spread out more evenly throughout the day, considerable excess capacity would exist (Meyer, Kain, and Whol 1965, 83-88). Thus, the urban transportation problem -- how to move people to and from employment and leisure activities in a city -- is a peak-period problem.  

I: Responses to the Urban Transportation Problem

At the most basic level, there are only two solutions to the urban transportation problem: (1) increase transportation capacity; or (2) decrease the demand for peak-period travel.

Supply-side responses attempt to improve traffic conditions by increasing the capacity of the transportation system. This may involve the construction or expansion of urban expressways, major arterial roads, mass transit systems, or bus services. Less obvious measures include improved traffic signal coordination, rapid removal of accidents, and driver information systems to help motorists avoid traffic bottlenecks.

\[2\] The term ‘urban transportation problem’ was used by Meyer, Kain, and Wohl (1965) in a book by the same title.
Demand-side responses attempt to reduce the demand for peak-period automobile travel, particularly single occupancy vehicle (SOV) travel. Such responses can be divided into carrot and stick methods. Carrot methods offer incentives to commuters to make better use of their private vehicles. Typical methods include high occupancy vehicle (HOV) lanes, which attempt to reward carpoolers with a faster trip, improved transit services, improved cycling facilities, ride sharing programs, and public advertisement campaigns. Stick methods penalize motorists for driving alone during peak periods. Such methods can be grouped into regulatory and market-based approaches. Regulatory methods mandate or prohibit certain travel behaviours (Downs 1992, 24). Examples include mandated employer-based trip reduction programs, banning trucks during peak periods, and local growth limits. Market-based approaches rely on travellers to select among alternate travel behaviours based on a set of prices (Downs 1992, 23). The most efficient outcome is achieved when prices are set to approximate the marginal costs of each travel alternative, although this is rarely accomplished in practice. Examples of market-based approaches include gasoline taxes, parking taxes, and road pricing.

**D: REASONS FOR RENEWED INTEREST IN ROAD PRICING**

Road pricing has long been advocated by economists as the only comprehensive, long term solution to the urban transportation problem (Field 1992, 5). Renewed interest in road pricing is a function of three forces: (1) the failure of traditional transportation policies to ease congestion; (2) changes in political attitudes; and (3) advances in electronic road pricing technology.
Failure of Traditional Policies

Traditionally, urban transport planning has been dominated by engineers, who have focused almost exclusively on supply-side responses to the urban transportation problem. This policy response has been largely unsuccessful. Despite significant investment in roads and urban expressways, traffic conditions in most major cities continue to deteriorate (Hau 1992a, 4). Downs’s Law of Peak-Hour Traffic Congestion (Downs 1962) provides insight into the failure of supply-side strategies. Downs’s Law states: “On urban commuter expressways, peak-hour traffic congestion rises to meet maximum capacity” (Downs 1962, 393). Downs’s Law is based on the forces of traffic equilibrium. In response to the opening of a new expressway, rush-hour commuters will adjust their travel routes until an equilibrium is reached between the time required to commute on the new expressway and the commuting time on existing routes (Downs 1962, 396). Because the expressway will normally represent a more direct route than other roads, equilibrium will not be reached until the speed of traffic on the expressway falls below that of existing routes. At equilibrium, traffic volumes on the expressway will almost always surpass the optimal level (Downs 1962, 397). In the case of cities with a significant reliance on rapid transit, Downs reaches the remarkable conclusion that “marked improvement of roads without an improvement in segregated track transit may cause automobile traffic congestion to get worse instead of better” (Downs 1962, 409).

Traffic restraint measures which are less onerous than road pricing have also proven ineffective: “No matter how many ‘solutions’ to the problem of urban highway congestion - ride sharing, mass transit, higher parking fees - are tried, the problem grows worse” (Small, Winston, and Evans 1989, 80). While less onerous policies than road pricing can produce important benefits, they will
not substantially reduce the severe congestion levels found in most large urban centres (Small, Winston, and Evans 1989, 85). Downs (1992) reports that of twenty-three anticongestion measures considered, only two could significantly reduce peak-hour traffic congestion unaided: “peak-hour road pricing on major traffic arteries and charging a sizable special fee for all parking during morning peak hours” (Downs 1992, 151). The effectiveness of parking surcharges is hampered by the lack of effect which parking charges have on through traffic and by the inability to tax private parking spaces (although this could be addressed through changes in legislation) (May 1992, 313-14). Road pricing may be the only feasible method of controlling the seemingly insatiable demand for private automobile travel in urbanized regions.

2: Changing Political Attitudes

While the failure of traditional policies to reduce congestion has been the primary impetus behind renewed interest in road pricing, two important political trends have contributed to road pricing’s resurgence. First, interest in road pricing has been stimulated by the general preference for using market-based as opposed to regulatory strategies to allocate scarce resources (Orski 1992, 159). Second, road pricing has benefited from the growing popularity of user pay approaches, in which government programs are funded from user fees rather than from general revenues. Recent discussions about imposing user fees for certain medical services provides an example of this shift in public policy (Toronto Star 08/27/93; Vancouver Sun 01/15/93). Despite these trends, political opposition remains the biggest obstacle to road pricing’s implementation.
3: Technological Improvements

Developments in technology have removed many of the practical impediments to road pricing. In particular, automatic vehicle identification (AVI) and electronic toll collection systems allow charges to be levied without impeding the flow of traffic (Orski 1992, 159). Furthermore, electronic systems afford the opportunity to design a flexible charging structure which closely approximates the social costs of driving. Advances in smartcard technology have helped to address the privacy concerns surrounding electronic road pricing. Once the strict domain of academics, technological advances have made marginal cost road pricing operational.

E: PURPOSE

The purpose of this thesis is to advance the use of road pricing as a tool of urban transportation policy. This purpose is achieved by outlining a framework for the development of a road pricing scheme in Greater Vancouver. Specifically, this thesis seeks answers to the following questions:

- Is road pricing an appropriate policy for Greater Vancouver?
- What should be the primary objective of road pricing?
- Should road pricing be applied in a comprehensive or piecemeal fashion?
- What should be done with road pricing revenues?
- How should road pricing be introduced to the region?
- How should road pricing be integrated with land use and transportation policy?

Appendix 1 contains a summary of electronic road pricing technologies.
Chapter 1: Introduction

F: RELEVANCE OF THE THESIS

The economic benefits of road pricing are well established in economic and transportation planning literature (Hau 1992b; Morrison 1986; Vickrey 1955; Walters 1961, 1968). The technology necessary for a flexible electronic road pricing system is "certainly very close to arrival, and indeed in some cases has been with us and operating for some time" (Thompson 1990, 526). However, despite technical advances and economic rational, political opposition has severely restricted the application of road pricing ideas. With relatively few exceptions, road pricing has yet to be implemented. The relevance of this thesis is that it attempts to bridge the gap between economic theory and political reality, so that the benefits of road pricing can be realized.

G: SCOPE

The economic theory of road pricing developed in this thesis is relevant to all cities. Discussions about road pricing's political aspects are spatially limited to cities in western, liberal democratic countries. The social and political structures and traditions in nonwestern countries are so different, that the conclusions reached by this thesis may be of little relevance.

Recommendations regarding the design of road pricing are limited to the Vancouver region, although many of these recommendations would also be relevant in other medium sized cities, which share Vancouver's more prominent characteristics.

H: METHOD

The introduction provides a context for the discussion of road pricing as a solution to the urban transportation problem and establishes the purpose of the thesis.
Chapter 2 illustrates the benefits of road pricing, both from a theoretical and empirical viewpoint. It is shown that maximum benefits are attained when the charge to motorists is set equal to the difference between the private and social costs of travel.

Chapter 3 provides a literature review of the politics involved in implementing road pricing. Where applicable, references are made to international experiences, a more detailed discussion of which are found in Appendix 3.

Chapter 4 summarizes the key elements of Greater Vancouver’s transportation network and provides background about transportation planning in the region.

Chapter 5 draws on the discussion of the economics and politics of road pricing and on the summary of transportation in Greater Vancouver, to make specific recommendations about how road pricing should be applied in the region.

Chapter 6 concludes the thesis with a summary of key findings and some thoughts on the future of road pricing.

For reference purposes, three appendixes are included at the end of the thesis. These appendixes contain a summary of electronic road pricing technologies, a description of charging structures, and a review of road pricing experiences in other countries.
CHAPTER 2
THE ECONOMICS OF ROAD PRICING

A: INTRODUCTION

The economic basis for road pricing is well established in the literature (Hau 1992b; Morrison 1986; Vickrey 1963; Walters 1961, 1968). In the absence of a set of road charges to account for the external costs of travel, motorists will make their travel decisions solely on the basis of private costs and benefits. However, because total travel costs exceed private costs, motorists are likely to undertake trips for which costs exceed benefits. This excess consumption of trips above that which is socially optimal exacts a significant welfare loss on society.

This chapter begins with a description of both the internal and external costs of road travel. The second section argues that the underlying cause of congestion is the public nature of roads. Using diagrams, a model of road transport is then formulated which illustrates the need for a system of charges to capture the external costs imposed on others by the private motorist. The pricing and investment implications of road pricing theory are then discussed. In support of the theoretical arguments, estimates of the benefits of applying road pricing in various cities are summarized. The chapter concludes with an explicit statement of how road charges should be set in order to maximize economic benefits.

B: THE EXTERNAL COSTS OF ROAD TRAVEL

The costs of road travel can be divided into two categories: internal private costs and external social costs. Private costs are those borne by the motorist. These include fuel, vehicle
maintenance, depreciation, time, and the private costs of accidents. External costs are those which are attributable to the private motorist but are borne by others. The principle external costs are: "accident externalities, environmental pollution, road damage, and congestion" (Newbery 1990, 24).

1: Accident Externalities

Accident externalities are the costs associated with the increased risk of accident caused by an additional trip. The size of accident externalities depends on the relationship between the accident rate and traffic flow (Newbery 1990, 24). If the accident rate rises considerably with traffic flow, then accident externalities are a significant external cost (Newbery 1990, 24). If the accident rate is independent of the traffic flow, then there is no external accident cost between motorists, although there may still be important accident externalities between motorists and nonmotorists (Newbery 1990, 24). In addition, all accidents impose some external costs on society in the form of socialized medicine.\(^1\) Where it is possible to estimate external accident costs, these should be charged to the private motorist.

2: Environmental Pollution

Motorized transport is a major contributor to pollution problems. Certain pollution costs, such as those associated with ozone, acid rain, and carbon dioxide build-up, are not time and place specific and hence could be effectively internalized through gasoline taxes (May 1993b, 7). Other types of pollution, such as noise and carbon monoxide, are exacerbated at low speeds (May 1993b, 7)

\(^1\)High taxes on products known to cause health problems, such as cigarettes and alcohol, are often justified by the existence of socialized medicine.
and can only be internalized through time and place specific road charges. Newbery (1990) reports that where pollution costs have been quantified in the United States, “they appear to contribute less than 10 per cent of total road costs” (Newbery 1990, 25).

3: External Road Damage Costs

External road damage costs include costs borne by the highway authority for periodic repairs to the road and added operating costs borne by other motorists associated with driving on damaged roads (Newbery 1990, 25). External road damage costs do not include road wear associated with weather conditions.

The road damage caused by a vehicle rises as roughly the third power of its weight per axle (Small, Winston, and Evans 1989, 11). Therefore, road damage costs can be attributed almost exclusively to trucks and buses (Small, Winston, and Evans 1989, 11). Recognizing the importance of the weight per axle, most road authorities “closely regulate axle configuration and maximum legal axle loads” (Newbery 1990, 25). Pricing policies should also be aimed at reducing the weight per axle. Certain pricing practices, such as charging by the axle or taxing tires, are counterproductive as they reward trucks with fewer axles and thus promote truck designs which cause excessive road damage (Small, Winston, and Evans 1989, 12).

Most road damage costs can be effectively internalized through gasoline taxes and special fees on heavy vehicles. However, such instruments may be inadequate in situations where road damage costs are much higher on certain facilities than on others. Such circumstances require place specific charges to accurately reflect external road damage costs. Using data for Britain, Newbery
(1990) estimates that road damage costs attributable to vehicles account for between 3.5 and 5 percent of total road costs (Newbery 1990, 27).

4: Congestion Costs

When motorists enter a crowded roadway, they not only experience delays due to congestion but also impose significant congestion costs on other drivers. These congestion costs are very time and place specific. When a road is relatively uncrowded, the addition of one more vehicle onto the roadway does not affect the travel times of other motorists. However, as the road becomes crowded, each additional motorist imposes substantial delay costs on existing vehicles; these costs are not considered by the additional motorist. Congestion costs cannot be appropriately internalized using the existing instruments of gasoline taxes, tire taxes, or vehicle registration fees. Internalizing congestion costs requires time, place, and direction specific charges on moving vehicles. Congestion costs are the most significant external cost of road travel (Newbery 1990, 29).

C: Congestion and the Public Ownership of Roads

The enjoyment of an uncongested road by one user is largely unaffected by the use of that road by other users. Such roads are nonrivalrous and are traditional examples of public goods (Hau 1992b, 4). Neoclassical economic theory dictates that pure public goods (goods which are nonrivalrous and nonexcludable) should be provided by the public sector and financed from general tax revenues (Hau 1992b, 4). During periods of peak demand, most urban arterial roads

---

2A nonexcludable good is one which it is impossible to exclude others from consuming (i.e. radio signals).
possess the characteristic of rivalrous consumption and are examples of congested public goods (Hau 1992b, 4). Such roads are overused because access to them is free. Rivalrous private goods, by contrast, are not overused because the price system serves to ration use among competing interests (Hau 1992b, 4). If roads are to be used efficiently, the road authority should simulate the workings of a competitive market by establishing a price system to ration road capacity during periods of scarcity (Hau 1992b, 7).

Road authorities have not responded in this way. Their traditional response to the problem of allocating scarce road capacity has been to allow motorists to queue for it. In most societies, queuing is accepted as an equitable method of resolving problems of scarcity. However, as illustrated by the following example, queuing is an economically inefficient substitute for the price system. Consider a congested tunnel for which motorists are forced to queue in order to gain entry. Under the assumption of zero transaction costs, if motorists were able to negotiate with each other about the order of entry to the tunnel, then some motorists near the front of the line would trade places with those further back in the line in exchange for an agreed upon payment. By definition, since no motorist is forced to trade places, any such deal must result in at least one of the motorists being better off and neither of the motorists being worse off. Thus, a Pareto improvement\(^3\) is achieved by allowing bargaining among the motorists.\(^4\)

---

\(^3\) A Pareto improvement is defined as an increase in the welfare of society which does not leave any individual worse off.

\(^4\) Adapted from Walters (1987).
Under such a system of bargaining, it is the price mechanism which serves to ration the available road space, whereas under the queuing system, people are forced to pay with their time as space is rationed on a first come - first served basis. Of course, no such system of bargaining among motorists is possible in a practical sense. Therefore, if road space is to be allocated efficiently, the road authority must simulate the private market by imposing a toll on the users of the roadway. In order to illustrate the appropriate level of the toll and the welfare gains resulting from its imposition, the next section develops a theoretical model of congestion and road user charges.

**D: AN ECONOMIC MODEL OF CONGESTION AND ROAD CHARGES**

The standard theory of congestion charges is based on an analysis of a homogeneous traffic stream, moving in a uniform direction on an uninterrupted stretch of roadway (Else 1986, 100). The relationship of particular interest to economists, that of travel cost and traffic flow, can be derived from an analysis of the relationship between travel time (T) and traffic density (D) (Morrison 1986, 87). Figure 1(a) illustrates that travel time rises at an increasing rate with increases in traffic density. By definition

\[ F = D \times \frac{L}{T} \]

(where L denotes the length of the roadway and hence L/T denotes vehicle speed). Since L is a constant, F is proportional to D/T, or the inverse of the slope of the line drawn from any point along T, back to the origin in figure 1(a). Hence, the point of maximum flow (G') in figure 1(b),

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5A practical example of a similar system of bargaining can, however, be found in the case of overbooked airline flights. In such cases, the airline offers passengers free or discounted future tickets in exchange for accepting the inconvenience of taking a later flight.
corresponds to point G in figure 1(a), the point at which the line drawn back to the origin is tangential to $T_D$ (Else 1986, 100).

The backwards bending relationship between travel time and traffic flow can be interpreted as follows. For traffic flows up to $F_{G'}$, increased travel time is more than offset by increased traffic density, resulting in increasing traffic flow. However, beyond $F_{G'}$, the roadway becomes so crowded that the increase in travel time for existing vehicles caused by the addition of one more vehicle onto the roadway causes traffic flow to decline, even though more vehicles are using the
road. Clearly, increasing traffic density beyond this point is inefficient, since the same traffic flow could be achieved at a higher speed (Morrison 1986, 88). Such a condition is typical of the stop and go traffic (called forced flow) found on uncontrolled freeways during the peak hours in most large metropolitan regions. In practice, transportation engineers attempt to prevent forced flow by controlling the rate of entry onto congested freeways through ramp metering (Wohl and Hendrickson 1984, 118-19).

In the absence of road pricing, above optimal congestion levels will usually occur because motorists fail to consider the delay costs imposed on others when making their travel decisions. In figure 2, the backwards bending portion of the traffic flow curve is omitted, since the optimal flow will never occur in this region. The social cost (SC) curve of figure 2 shows the costs incurred by all motorists as a result of the addition of one more vehicle onto the roadway. The private cost (PC) curve shows the cost of entry onto the roadway incurred by the private motorist. In the absence of tolls, this is the only cost which the motorist considers. When the level of traffic is low, the social cost of travel is equal to its private cost, since the addition of one more vehicle onto the roadway has no effect upon the travel times of existing vehicles. However, as traffic levels and flow increase, the delay costs imposed on other motorists begin to increase rapidly and the SC curve rises steeply.

The demand curve in figure 2 shows that the marginal benefit of each additional trip declines with increasing traffic quantities. The optimal number of trips in figure 2 occurs at $Q^*$, the level at

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6For all levels of traffic flow below the maximum level, there is a one-one relationship between traffic quantity and traffic flow. Hence, figure 2 also shows the relationship between travel cost and traffic flow over the relevant range.
which the social cost of the last trip is exactly equal to its benefit. However, in the absence of congestion charges to capture the external costs not borne by the private motorist, motorists will demand trips up to the point $Q'$, the point at which the marginal benefit of the last trip is equal to its private cost. Despite their appeal to the private motorist, the benefit of all trips beyond $Q'$ is less than their cost to society, and hence such trips should not be undertaken. In the absence of a road charge to confront motorists with the full costs of travel, $(Q' - Q^*)$ trips are undertaken for which costs are greater than benefits. The welfare loss to society resulting from these trips is
shown by the shaded area in figure 2 (Morrison 1986, 88). In order to restrict the demand for trips to $Q^*$, a toll must be charged to impose the external costs of travel on the private motorist. This toll ($t$) should equal the difference between the social cost of the trip to society (the SC curve) and the private cost borne by the motorist (the PC curve), evaluated at $Q^*$ (Morrison 1986, 88). After imposition of the toll, the motorist will consider the full costs of travel, and hence will only make trips that result in a net benefit to society. 7

1: A Pricing Rule for Road Transport

The short run pricing rule that “price should be equal to the marginal cost of supplying the [road] service” (Walters 1968, 32) is consistent with the above analysis. The price charged for using a road should include all costs related to a particular journey that are currently not borne by the motorist. Such costs would typically include delay costs imposed on other motorists, variable maintenance costs imposed on the road authority, and environmental and accident costs imposed on society at large. Roadway costs which do not vary with usage (i.e. initial infrastructure costs or maintenance costs due to weather or time) should not be charged to the motorist. To do so would unnecessarily deny trips to motorists for which net benefits exist.

The above pricing rule suggests that the price charged for road space on lightly travelled country roads should be very low while the price charged for driving on congested urban streets during the peak-period should be very high. It should be remembered, however, that the size of the toll must

7For illustrative purposes, this analysis has focused on external congestion costs. Other social costs of driving, such as pollution, noise, road damage, and accident costs should also be included when deriving the SC curve.
be calculated at the final level of traffic flow, not that which existed prior to the toll’s imposition. Therefore, it is important for the analyst to know both the shape of the demand curve and the values of the elasticity of demand over the relevant range (Walters 1987, 573). As a broad guideline, Walters (1987) estimates the optimum toll for city traffic during the peak periods at between 50 and 100 percent of the private cost of the journey.

2: Road Investment Policy under Marginal Cost Pricing

Under competitive market conditions, prices serve the dual functions of rationing scarce resources and providing important signals for the viability of future investments. The existence of above normal rates of return on capital equipment provides a signal for the private firm to expand production (Hau 1992b, 21). Expansion will occur until excess profits have been reduced to zero, at which point, under constant returns to scale, the firm will cover its fixed and variable costs and earn a normal rate of return on invested capital (Hau 1992b, 22).

The same analysis applies to roads under marginal cost pricing. If the tolls collected by the road authority exceed the long run costs of maintaining the road network (allowing for a normal rate of return), then the road authority should expand the road network. If the tolls do not cover the costs of the network, then this is a signal that the road system is overbuilt (Hau 1992b, 22).

In practice, it may not be possible to rely on price signals to guide road investment policy. First, it is impractical to compute or collect a charge for every road segment. Second, even on larger roads where toll collection is practical, there may be insufficient traffic to warrant the imposition of road charges; nonetheless, the roadway may be needed to provide access to certain areas. Third,
it may not be desirable or possible to expand the road network in certain locations, despite clear price signals that expansion should occur. It is likely that road authorities will continue to rely on cost-benefit analysis as the principle method of choosing among alternative road investment projects (Churchill 1972, 16).

**E: Estimates of the Benefits of Road Pricing**

Most of the benefits of road pricing would be realized through time savings to travellers. Because these benefits are difficult to measure, the estimates presented below should be considered a rough guide rather than a precise forecast of the likely benefits of road pricing.

In the United States, a 1982 study by the Federal Highway Administration estimated that implementing efficient tolls throughout the United States would result in net benefits of $5.65 billion, based on 1980 congestion levels (Decorla-Souza and Kane 1992, 299). A Texas Transportation Institute study found that congestion in 39 major U.S. urban centres cost $41 billion in 1987 dollars (Decorla-Souza and Kane 1992, 299). "A large portion of these costs could be saved with tolls based on marginal social costs" (Decorla-Souza and Kane 1992, 299).

In Britain, a 1964 study of road pricing commissioned by the U.K. Ministry of Transport estimated that a system of time specific road user charges applied in the urban areas would generate net benefits of £100 - £150 million per year (U.K. Ministry of Transport 1964, 8). A 1974 Greater

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8Downs (1992), also referring to the Texas Transportation Institute Study, reports that 1988 congestion costs in 39 large urbanized areas in the United States exceeded $34 billion (Downs 1992, 2).
London Council study of central area licensing for London estimated net benefits of £24 million under the optimal scenario (May 1975, 165).

Studies carried out as part of the Hong Kong electronic road pricing experiment estimated that under the optimum toll of HK$10 (US$1.28), the annual net benefits of road pricing were HK$1,250 million (US$160 million) in 1985 dollars (Hau 1992a, 45).

Simulations carried out in Oslo, Norway found that the present flat rate toll charged to enter the City Centre produced a net loss (net of implementation costs) to society of NOK79.6 million (US$12.7 million). The optimal cordon toll scheme was estimated to produce a net benefit of NOK20.3 million (US$3.2 million) while the net benefits of an electronic pricing scheme based on true marginal costs were estimated at NOK80.9 million (US$12.9 million) (Hau 1992a, 41-42).\(^9\)

**F: CONCLUSION**

The benefits of road pricing are firmly established in economic theory. This chapter has shown that in the absence of a system of road user charges to capture congestion and other external costs of driving, a larger than optimal number of trips will be undertaken resulting in a loss of welfare to society. By confronting motorists with the true costs of their actions, the number of trips will be reduced to an economically efficient level and society will be better off. If the external costs of driving are high, then the loss of welfare caused by inefficient pricing is significant. Desk

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\(^9\)See Appendix 2 for a description of alternate road charging structures.
This chapter provides a conceptual basis for calculating road charges. If maximum economic benefits are to be attained, then:

- The price charged to motorists for the use of the roadway should be equal to the difference between the cost of the trip incurred by the motorist and the cost of that trip to society.

This requires a flexible system with charges varying by time, day, direction, and vehicle type. The road charge during heavily congested peak periods would be quite high in order to account for the large external delay costs and added pollution costs arising from slow moving traffic. During relatively uncongested off-peak hours, the charge would be very low (probably 0) to reflect the near absence of external costs. Furthermore, the charge for trucks would be higher than for cars, reflecting both the added delays caused by trucks as well as the road damage costs not presently internalized through existing instruments.

Despite overwhelming evidence of its economic benefits, road pricing has yet to be implemented on a wide scale. While the technical impediments to road pricing have been largely removed (see Appendix 1), political opposition remains a formidable obstacle to implementation. In order to make road pricing more politically attractive, future proposals will have to make tradeoffs between economic principles and political realities. Having established its economic rationale, the next chapter explores the political issues raised by road pricing.
CHAPTER 3
THE POLITICS OF ROAD PRICING

A: INTRODUCTION

Political opposition is the biggest barrier to the implementation of road pricing. Faced with congestion and pollution problems, a number of cities have studied and planned for a system of road charges, only to have their plans derailed by public opposition. Notable examples of such failures include the Smeed Report examining road pricing for London (U.K. Ministry of Transport 1964) and the Hong Kong electronic road pricing experiment (Dawson and Catling 1986; Hau 1990). Recent road pricing proposals in the Netherlands have also been stalled by political opposition (Hau 1992a, Stoelhorst and Zandbergen 1990). To date, the only operational road pricing system explicitly designed to reduce congestion is the Area Licensing Scheme (ALS) in Singapore (Menon, Lam, and Fan 1993; Pendakur 1987).\(^1\), \(^2\)

Given the above failures, an examination of the political forces at work in the road pricing debate is essential. A successful road pricing system must be more than technically and economically efficient; it must be designed so that the overall package is politically palatable as well. Unfortunately, many transport professionals have traditionally not paid enough attention to political considerations in the design of road pricing schemes, and have instead focused on economic and

\(^1\)Toll rings also exist in the Norwegian cities of Bergen, Oslo, and Trondheim. In Trondheim, the charge does vary slightly by time of day, while Bergen and Oslo charge a flat rate toll. The primary objective of these systems is to raise revenue rather than to reduce congestion, and hence they are not considered road pricing schemes (Poole 1992, 384).

\(^2\)For a detailed description of road pricing experiences in various countries, see Appendix 3.
technical issues. This has resulted in plans that were less than optimal if considerations of public acceptability are included and in proposals being presented to politicians that were difficult to sell to the general public (Jones and Harvey 1991, 295).

Despite deteriorating traffic conditions, high costs of road building, strained public finances, and a greater appreciation for the environmental effects of the automobile, most cities have yet to seriously consider a comprehensive system of road user charges. This relative lack of interest in an idea that has long been advanced by economists and other transport professionals, stems from the fact that charging for road space is a controversial issue which most politicians would prefer to avoid. The controversy surrounding road pricing arises for the following reasons: (1) the pricing of roads represents a big change in transport policy which would affect almost every user of transport services (private or public); (2) charging for road use is seen by many people as an infringement of their fundamental 'right' of mobility; and (3) road pricing has potentially large distributional effects which are poorly understood by the public and about which there is no clear consensus among transport professionals.

The purpose of this chapter is to identify factors affecting the political acceptability of road pricing and advance some ideas about how a system of road user charges can be designed to appeal to as many citizens as possible. The chapter begins by identifying five principle objections to road pricing. These objections are evaluated in terms of the likely results of road charges; where possible, suggestions are made for the design of a road pricing system to accommodate these criticisms. The second section of the chapter examines the distributional effect of road pricing and its implications for political acceptability. A list of winners and losers is developed for the case
where road charges are implemented on an existing free facility. It is shown that where tolls are applied to new road projects, the list of losers is narrowed considerably. This explains the observed tendency of the public to accept tolls on new but not existing facilities. Interest groups and stakeholders in the road pricing debate are then identified. If road pricing is to gain public support, the needs and wants of these interest groups should be addressed. The next section considers the important question of what governments should do with road pricing revenues. Five alternate strategies for implementing road pricing are then evaluated in terms of their effectiveness at reducing congestion and acceptability to the public. The chapter concludes with a set of criteria for designing a politically acceptable road pricing scheme.

B: OBJECTIONS TO ROAD PRICING

1: Equity

Opponents often claim that road pricing will benefit the rich at the expense of the poor by forcing low income drivers off the road. High income drivers will be able to travel at the most convenient times while low income drivers will be relegated to less convenient times of the day (Downs 1992, 51). In cases where no viable alternative mode of transport exists, road pricing may cause undue hardship to low income motorists since they will not be able to avoid paying the toll if their peak-period trips are work related or time specific for other reasons. Although the distributional characteristics of road pricing are dependent on a number of different factors relating to how and where road charges are introduced (see the discussion of winners and losers below), in the absence of any form of revenue redistribution, road pricing will tend to be regressive (Else 1986, 106).³

³As Else (1986) also points out, this may not be the case if the value which people attach to time savings varies more with circumstance (i.e. type or time of trip) than with income level.
There are a number of options available to planners to reduce the regressiveness of road pricing. The simplest of these options is to direct road pricing revenues towards projects which benefit lower income groups or to use such revenues to reduce or eliminate regressive forms of motor vehicle taxation. A slightly more complex approach is the mobility tax credit. Under such an approach, all commuters would be given a credit to be used for commuting purposes. Commuters would be free to select among alternate transport forms, given the costs and convenience associated with each mode. Such an approach would help to compensate commuters for the added costs of driving or the reduced convenience of using transit without skewing the relative costs of alternate travel modes. Finally, electronic road pricing systems provide many opportunities to address equity concerns. Some examples of how this might be done include: (1) varying charging rates by the number of units consumed; (2) providing a free ration of units on a monthly (or yearly) basis; or (3) varying charging rates by engine size or vehicle value (as a proxy for income) (Jones and Harvey 1991, 310).

While equity is often cited as a major obstacle to road pricing, it is unclear how much considerations of equity affect its political acceptability (Giuliano 1992, 348). Gasoline taxes have been raised in both Canada and the United States without much public debate about the effect on low income drivers. Similarly, high downtown parking charges have been accepted despite being regressive in nature. Public opposition to Canada’s much maligned Goods and Services Tax (GST) has been based on its visibility, rather than on its regressive nature. Likewise, provincial

Nevertheless, it seems reasonable to assume that people of lower incomes generally attach a lower monetary value to their time.

The Canadian Government did, however, institute a credit to low income Canadians to partially compensate for the regressive nature of the GST.
revenues from sales taxes and lotteries have increased significantly in the past decade without much public opposition based on concerns for equity. While road pricing raises important questions of equity and fairness which should be addressed, objections based on equity “may present an apparently legitimate basis for opposition that is actually motivated by other reasons” (Giuliano 1992, 349).

2: Scepticism Regarding the Effectiveness of Road Pricing

Despite evidence from simulation studies that road pricing is an effective means of reducing congestion, some opponents remain sceptical of the ability of road charges to influence travel behaviour (Giuliano 1992, 350). Such critics argue that the demand for road space is very insensitive to price and that road charges would not significantly reduce traffic levels (Jones and Harvey 1991, 308).

Evidence from Singapore contradicts this view.\(^5\) Prior to the introduction of the Area Licensing Scheme (ALS) in 1975, car drivers represented 47 percent of commuters in the morning peak (7:30-10:15 a.m.). By 1983, this had fallen to 15 percent while the proportion of bus passengers had risen from 33 to 69 percent (Pendakur 1987, 212). Furthermore, the number of inbound cars entering the restricted zone during the morning peak was immediately halved following introduction of the ALS (Pendakur 1987, 212). While it is difficult to isolate the effects of the ALS from those of the broad package of transportation reforms introduced by the Government of

\(^5\)Appendix 3 provides a more detailed review of Singapore’s Area Licensing Scheme.
Singapore around 1975, charging for entry into Singapore's central area has undoubtedly affected Singaporeans' commuting patterns.

3: Invasion of Privacy

A principal objection to emerging electronic road pricing technology is that it compromises people's right to privacy. Concern for privacy was one of the main reasons why Hong Kong's electronic road pricing experiment was abandoned in 1985 (Downs 1992, 58). This fear was reinforced by the pending return of Hong Kong to the Chinese authorities in 1997 (Jones and Harvey 1991, 309).

Electronic road pricing relies on the ability of the system to detect the presence of a vehicle and to calculate the appropriate charge. At a minimum, the system must be able to detect when a vehicle passes a specific point in the roadway and be able to charge that vehicle for use of the road. Privacy concerns can be reduced by allowing drivers to select a nonitemized billing option with details removed from the system's central computer (Downs 1992, 58). Such a system has the obvious drawback that it is difficult for drivers to query charges which they feel are in error.

Privacy concerns can be further reduced by allowing car owners to purchase a smart card which would automatically be debited when the vehicle passes a charging point. This would eliminate the need to identify the vehicle except in cases where the card had no remaining value (May 1992, 6).

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6Appendix 3 provides a more detailed review of Hong Kong's electronic road pricing experiment.

7See Appendix 1 for a discussion of electronic road pricing technologies.
Drivers could protect their privacy by maintaining a minimum balance (Downs 1992, 58). Such a system currently operates on toll roads in Texas, Louisiana, Oklahoma, New Jersey, Pennsylvania, and New York (Downs 1992, 58).

Finally, it is worth noting that consumers routinely accept possible invasion of privacy when purchasing other services. Examples include telephone calls (except those made from call boxes), credit cards, and banking machines. The almost universal acceptance of these services suggests that objections to road pricing based on privacy concerns may be overstated.

4: Effects on the Economy

Some business owners have expressed fears that road pricing would put them at a competitive disadvantage relative to other areas where access was free. Giuliano (1992) argues that such fears are unfounded and illustrate a misunderstanding of the concept of congestion pricing:

Congestion pricing theory suggests positive effects: congestion tolls reduce the full cost of travel; thus the targeted area would have a competitive advantage relative to areas that remain subject to congestion, as long as toll revenues remain within the targeted area. (Giuliano 1992, 351)

Results of the Singapore Area Licensing Scheme (ALS) indicate that the system has not negatively affected sales in the central area and that the availability of labour has improved as a result of improved public transport linkages (Morrison 1986, 94).

May (1992) stresses that impacts on the economy can be affected by the way in which road pricing is presented. Where road pricing is presented as a means of promoting mobility and efficiency it
is likely to have a positive effect on local businesses; however, if road pricing is seen as an attack on mobility and freedom of choice, the opposite effect is likely to result (May 1992, 327).

5: Road Pricing as a Form of Taxation

Those who believe that government is already too big will oppose road pricing as 'just another tax' (Downs 1992, 52). However, if road pricing is presented as a user fee rather than a tax, it is likely to be more politically palatable. In order to gain political acceptability, a clear link must be established between road pricing revenues and transportation expenditures or reductions in other transport fees (such as gasoline taxes or licensing fees) (Downs 1992, 53; Giuliano 1992, 350). The use of revenues is an important determinant of public acceptability and will be considered in depth later in this chapter.

C: Distributional Considerations and Political Acceptability

Distributional considerations affect the political acceptability of road pricing in two important ways. First, and most obviously, the incidence of road charges does not fall evenly across all members or groups in society. Although road pricing is likely to result in large net benefits, there will be a number of individuals and groups who find that they have suffered as a result of road pricing. The relative size of the winning and losing groups and the size of their gains and losses will help determine public reaction to road pricing. Distributional effects are also important in determining the acceptability of road pricing based on equity concerns. If the benefits of road charges are perceived to be divided along income lines, road pricing may be rejected as a policy which benefits the rich at the expense of the poor.
In order to analyze the distributional effects of road pricing, it is necessary to consider both what the alternative to road pricing is and how comprehensively the system is implemented (Gomez-Ibanez 1992, 347). There are two alternatives to consider: (1) in the absence of tolls, the road would continue to exist (or would be built) and access would be free (tolling an existing road); and (2) the road will not be built unless tolls are charged for its use (tolling a new road) (Gomez-Ibanez 1992, 347).

1: Tolling an Existing Road

a. Winners and Losers

Winners

(1) Motorists who would drive with or without the toll but who place a high value on travel time savings (for these motorists the gains from improved traffic speeds outweigh the toll costs);

(2) Travellers who would use bus or high occupancy vehicle (HOV) services on the tolled road whether or not tolls are charged (they benefit from improved speeds while paying little or no toll); and

(3) Recipients of toll revenues (i.e. taxpayers if tolls reduce the pressure for tax increases or, alternatively, the clients of government programs if tolls are used to finance an expansion of government services).

Losers

(4) Motorists who would continue to drive on the road despite the toll but who place a relatively low value on travel time (even though the time savings does not compensate these motorists for the toll charge, driving the tolled road may still be worthwhile because alternate routes or HOV services are too inconvenient for trips they are making);

(5) Motorists who shift from the tolled road to a competing untolled facility (the untolled facility is less convenient, otherwise these motorists would have used it even in the absence of tolls);
(6) Other users of the competing untolled roadway (since congestion will increase on that road);

(7) Motorists who choose not to make the trip at all because of the toll (or who, with congestion pricing, now drive at a less convenient time of day when the tolls are lower).

Unknown

(8) Travellers who switch from driving to HOV or bus services on the tolled road (some of those who switch may benefit if the HOV or bus speeds are improved greatly by the tolls, but others may lose if the bus or HOV speed improvements are modest or these modes were fairly inconvenient to begin with).

(Gomez-Ibanez 1992, 348)

Hau (1992b) illustrates that except for the case of forced flow, the imposition of road pricing will leave road users, as a group, worse off; in the absence of revenue distribution, the government will be the chief beneficiary of road pricing (Hau 1992b, 14-16). Unless revenues are channelled back to road users or at least to travellers in general, motorists are unlikely to support road user charges (Hau 1992b, 17).

b. Is Road Pricing Regressive?

This list indicates why it is difficult to determine, a priori, to which income group the benefits of road pricing are likely to flow. Among winners, those whose value of time savings is greater than the cost of the toll are likely to be of higher incomes while bus and HOV lane users are likely to be of more modest incomes (Gomez-Ibanez 1992, 349). Among losing groups, those whose value of time savings is less than the cost of the toll are likely to be of low income as are motorists who switch to a less convenient facility or time of day. Users of competing facilities may be of high or low income.
As road pricing revenues are likely to be very large, the income characteristic of the beneficiaries of these revenues (group 3) is the most important determinant of road pricing’s distributional nature. If the monies collected from road pricing replace a regressive tax or are targeted towards low income groups, then road pricing is likely to be either progressive or have no net redistributive effect. In the opposite case, road pricing will be regressive (Gomez-Ibanez 1992, 349). If revenues are not redistributed in any way, road charges are likely to be regressive as the losing groups described above are predominately of lower incomes (Else 1986, 105-6).

c. Effects of the Comprehensiveness of the Charging System

The list of winners and losers also demonstrates how the comprehensiveness of the pricing scheme can affect its political acceptability. To the extent that competing facilities are tolled, not all users of such facilities (group 6) will be harmed by road pricing (Gomez-Ibanez 1992, 350). Rather, such users will be divided amongst winners and losers as described above. Conversely, such a policy is likely to be viewed as unfair since it removes the option of switching to an untolled facility for those who wish to avoid the toll.

d. Congestion Levels and Political Acceptability

This list also explains why road pricing is likely to be more acceptable where traffic congestion is worse (Gomez-Ibanez 1992, 349). The number of bus and HOV users (group 2) tends to be larger in more congested areas. Furthermore, bus and HOV services are likely to be more extensive in congested areas and hence the number of winners in group 8 (motorists who switch to bus or HOV services) will be larger (Gomez-Ibanez 1992, 349). Finally, greater congestion will tend to increase the number of motorists whose time savings from road pricing exceed the cost of
the toll (group 1). Road pricing will be particularly attractive in areas where forced flow frequently occurs. Where road charges can prevent forced flow, the number of winners will be large and the number of losers small (Gomez-Ibanez 1992, 349). Some motorists may still find the costs of the toll greater than the time savings, but forced flow is so inefficient that preventing it is likely to gain widespread approval (Gomez-Ibanez 1992, 349).

e. Winners, Losers, and Political Activism

Finally, the list of winners and losers suggests that those who benefit from road pricing may be harder to mobilize politically than those who are harmed by it. Among winners, motorists who place a high value on time as well as bus and HOV users (groups (1) and (2)) are likely to support road charges; however, in advance of road pricing their gains are speculative and hence their enthusiasm is likely to be somewhat tempered (Gomez-Ibanez 1992, 350). The recipients of toll revenues, group (3), may be a very large group (i.e. all taxpayers), but gains to individual members are likely to be small and hence this group may also be difficult to mobilize (Gomez-Ibanez 1992, 350). By contrast, the effect upon losing groups is more direct and severe, and these groups are likely to be more vocal in their opposition. Motorists who place a low value on time savings but have no viable alternative to using the tolled road, as well as motorists who avoid the toll by taking a less convenient route or by driving outside of the peak-period will perceive an obvious and tangible inconvenience caused by road pricing (Gomez-Ibanez 1992, 350).
2: Tolling a New Road

When expansion of the road network is completely financed by tolls, all motorists are better off (Gomez-Ibanez 1992, 351).\(^8\) Motorists who use the new facility and pay the toll are better off or they would continue to drive on the road which they used prior to the new facility being built. Motorists who continue to use the same roadway as before are either better off or unaffected. Since tolls cover the cost of the project, these motorists are not burdened financially by construction of the new road. Furthermore, they are likely to find their routes less congested than before, as some motorists switch to the new facility (Gomez-Ibanez 1992, 351).

This simple analysis does not imply that there are no losers when new roads are financed through toll revenues. Local residents may be harmed by noise, traffic, pollution, and neighbourhood disruption. In addition, as the dynamics of urban land development adjust to the construction of the new roadway, many other residents may be upset by the changing character of their neighbourhoods and the increased commercial, retail, or industrial uses that improved accessibility is likely to encourage. Furthermore, improvements in traffic flows brought about by the new roadway are likely to be reduced over time, particularly if the new facility promotes urban sprawl and increased automobile use. Nonetheless, in the short term, the number of losers from the construction of a new road financed through toll revenues is likely to be small.

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\(^8\)Because road expansion occurs in discrete rather than continuous units, new roads are likely to be relatively uncongested, at least in the short term. Hence, in order for a new road to be completely financed from toll revenues, the toll will generally have to be higher than that dictated by marginal cost pricing.
The above discussion illustrates why most tolls in North America have been implemented on new rather than existing roads. Recent toll road proposals in California demonstrate that tolls are acceptable to the public where it is recognized that the road would not be provided unless tolls are applied (Gomez-Ibanez 1992, 351-52; Wachs 1991, 278). While more politically feasible, the benefits of applying tolls (particularly if they are not based on marginal cost) to new roads are far less than the benefits which would result from a comprehensive application of road charges on existing facilities.

D: INTEREST GROUPS AND STAKEHOLDERS IN THE ROAD PRICING DEBATE

In assessing the political feasibility of road pricing, it is useful to identify major stakeholders and interest groups.

1: Motoring Associations

High automobile ownership levels make motoring associations a powerful lobby group. Motoring associations are interested in low vehicle and gasoline taxes as well as relief from congested streets. They argue that motoring taxes are already too high and resist arguments that motorists are subsidized by the nonmotoring public. Policy 2.3 in the policy manual of the Canadian Automobile Association (CAA) states: “All highways, roads, streets and bridges should be free of tolls” (Canadian Automobile Association 1993b, 9). However, the recommendations following the policy refer only to tolls which are designed to pay for infrastructure, rather than tolls designed to reduce congestion. The association would support tolls under certain conditions, one of which being that “the tolls would be removed immediately upon completion of collecting the construction
cost of the road" (Canadian Automobile Association 1993b, 10). Motoring associations are likely to be sceptical of any scheme that would increase the cost of driving.

Nonetheless, many motorists are aware that government fiscal restraint means that few new roads are likely to be built without new revenue sources. The 1993 CAA Public Policy Survey found that a majority of respondents would support tolls under certain conditions. In response to the question: “If your provincial government were to consider highway tolls, which of the following conditions would you want placed on the toll?” only 32.59 percent of respondents answered: “I would not want tolls in any situation” (Canadian Automobile Association 1993a, question 26). Support for toll highways in California, as well as the recently announced construction of the 407 toll highway north of Toronto, indicate public acceptance that future highway projects will only be built if funded by some form of user fees.

Although discussions about the reaction of motorists to road pricing tend to focus on motorists as consumers of road services, it is worth noting that motorists are also the primary contributors to the road system. As contributors, motorists are interested in road pricing as a means of making more efficient use of road investments. The key to gaining the support of motorists will be to convince them that the value of efficiency gains and transportation improvements resulting from road pricing will be greater than the monetary costs and added inconvenience that road pricing will impose.
2: Transit Advocates and Riders

Transit advocates and riders are likely to support road pricing for two reasons. First, road pricing represents a potentially large source of revenue to fund transit capital projects and operating expenses. Furthermore, by discouraging driving in the peak period, road pricing will reduce the need to build new roads, thus freeing up more of the existing transportation budget for transit expenditures. Second, road pricing will result in more people using public transit. Provided that this is accompanied by a commensurate increase in transit investment, existing transit riders will experience an improvement in the frequency of service. Increased ridership levels will encourage governments to invest in more rapid transit facilities further improving transit services. Increased ridership levels will also benefit transit unions, managers, equipment makers, and other members of the ‘transit establishment’ by increasing the employment and business opportunities in this sector.

3: Nonmotorists

In 1991, there were 17,223,039 road motor vehicles registered in Canada, or one vehicle for every 1.58 residents (Statistics Canada 1992). There are more than 1 million vehicles registered in British Columbia’s lower mainland, or 1.5 vehicles per dwelling unit (KPMG 1993, 14). Over 70 percent of Lower Mainland residents own a drivers licence (KPMG 1993, 14). Although the nonmotoring lobby is not large, they are nonetheless an important group in the road pricing debate.

Nonmotorists have an interest in rationalizing road use for a number of reasons. First, to the extent that costly road construction projects and repairs are paid for out of general tax revenues, road pricing will reduce a component of government spending from which nonmotorists derive a
disproportionately small share of benefits. Second, road pricing represents a means of internalizing the external pollution, noise, and accident costs imposed by motorists on the nonmotoring public. Third, revenues received from road pricing can be used to fund improvements to alternate transport forms such as walking, cycling, and transit; such improvements would directly benefit the nonmotorist. Finally, since high congestion levels increase the cost of goods transport, nonmotorists, like all residents, would benefit from a more efficient use of the road network.

4: Environmentalists

In recent years, heightened public awareness of the environmental effects of the automobile has influenced public policy in the areas of emission standards, air quality targets, and highway construction (Small 1992b, 364). These successes illustrate the influence and support which environmental advocates command.

Environmentalists tend to see road pricing as a means of changing human behavioral patterns, a change which may be necessary if the gains in air quality that have thus far been achieved through technological innovation are to be sustained. However, the beneficial environmental effects of road pricing will only be realized if motorists can be persuaded to switch to public transit or car pools rather than shifting their trips to the off-peak period. A simple approach which estimates the reduction in peak-period trips as a result of road pricing will tend to overstate the beneficial effects on air quality; many of these former trips are likely to be made during the off-peak, negatively affecting traffic speeds and emissions during this period (Decorla-Souza and Kane 1992, 305).
In the longer term, road pricing is attractive to environmentalists because it promotes increased urban densities. More compact cities reduce development pressures on environmentally sensitive areas, increase the potential for walking, cycling, and public transit, and generally lead to a reduction in automobile use and total emissions.

5: Business Interests

Business interests rely on efficient transportation systems to support their activities. However, they seek solutions to congestion problems which allow for flexibility (Small 1992b, 364). Furthermore, business interests are weary of overly costly transportation improvements for fear that business taxes will be raised to pay for them. Business people often demand more accountability from government and would likely insist that road pricing revenues be dedicated to transportation improvements or used to offset other forms of vehicle taxation. Despite this important caveat, when faced with the prospect of increasing congestion, rigid regulations, or road pricing, business interests are likely to favour the market-based approach of road pricing over the other alternatives.

Perhaps the best example of support for road pricing by the business community is the Bay Area Economic Forum, a public/private interest group organized to develop market-based strategies to meet air quality standards in the San Francisco Bay Area (Giuliano 1992, 342). The Forum was organized in response to the ‘command and control’ approach adopted by the South Coast Air Quality Management District (SCAQMD) to reduce air pollution from automobiles in Greater Los Angeles (Giuliano 1992, 341). SCAQMD’s more onerous regulations include making employers responsible for implementing ride sharing programs and for ensuring that at least 20 percent of their workers telecommute (Gomez-Ibanez 1992, 352-53). Many business people find the peak-
period bridge tolls and increased parking fees proposed by the Bay Area Economic Forum preferable to the more rigid approach adopted by SCAQMD in the Los Angeles Area (Giuliano 1992, 342).

6: Taxicab and Trucking Industries

Support for road pricing by the taxicab and trucking industries is dependent on how these industries are treated under the proposed system. If taxis are charged a reduced toll and/or are allowed to pass on the increase in costs to their customers, they will likely support road pricing on the basis that it would reduce congestion and therefore increase taxicab profits (Small 1992b, 363).

Trucking companies have a substantial interest in reducing congestion because it increases and adds uncertainty to the time required to make deliveries. In addition to reducing their ability to provide quality service, trucking companies incur excess wage and fuel costs as a direct result of congestion. Provided that tolls for trucks are set at a reasonable level relative to cars, the trucking industry is likely to gain substantially from the imposition of congestion-based road charges. The industry is also aware that many see trucks as a primary cause of congestion; truckers would much prefer the flexibility of road pricing to the restrictions on truck movements proposed in the Los Angeles area (Small 1992b, 364).

E: The Problems and Opportunities of High Toll Revenues

For political reasons, road charges are unlikely to be set as high as most economists would recommend; nonetheless, tolling in heavily congested areas is likely to produce the mixed blessing
of a very large revenue stream (Gomez-Ibanez 1992, 356; Giuliano 1992, 349). Large revenues create both the opportunity to placate those who are harmed by and thus opposed to road pricing as well as the problem of the political controversy regarding how these revenues should be spent.

Experience in the United States has shown that special taxes and user fees are likely to gain public support only after the use of revenues is clearly linked to projects which are in the interests of those paying the tax or fee (Giuliano 1992, 350). Recent survey work in London regarding public attitudes towards road pricing found similar results; support for road pricing increased from a net rejection of 27 percent when respondents were presented with the idea in isolation to a net support of 23 percent when respondents were told that the revenues from road pricing would be used to improve public transport, reduce accidents in residential areas, and provide better facilities for pedestrians and cyclists (Jones and Harvey 1991, 302-3).

The two groups most likely to be concerned with the use of road pricing revenues are motorists who pay the toll but whose value of time is low and motorists who switch to a different mode of transport or travel in the off-peak in order to avoid paying the road charge (groups 4 and 5 above). Despite benefiting from road pricing, motorists whose value of time is high (group 1) will also be concerned about how toll revenues are spent. These groups are likely to insist that proceeds from road pricing be spent on transportation infrastructure and services in the corridor in which tolls are collected. However, particularly in built up areas where the costs of expanding the transport network are very high, the revenues from road charges are likely to swamp sensible investment requirements (Gomez-Ibanez 1992, 359). Furthermore, since road pricing will lead to a more efficient use of existing facilities, the need for additional transport capacity will be reduced. In
most cases, it will not be desirable to return all of the proceeds from road pricing to travellers in
the form of additional transport investment. A more creative approach to the problem of toll
revenues is therefore required.

I: Guiding Principles for the Use of Road Pricing Revenues

In theory, since the pricing of roads in heavily congested areas will result in a large increase in the
welfare of society, it should be possible to fully compensate everyone who suffers as a result of
road pricing. In practice, revenues cannot be targeted towards individual travellers and must
instead be directed towards groups of individuals. Even so, the benefits and revenues from road
pricing may be large enough to more than offset any negative effects of road charges, and have
“money left over to promote general social goals and garner political support” (Small 1992b, 365).

Small (1992b) recommends that toll proceeds be allocated equally between the following three
categories:

1. monetary reimbursement to travellers as a group;
2. substitution for general taxes now used to pay for transportation services; and
3. new transportation services.

(Small 1992b, 365)

These guidelines avoid linking toll revenues to expenditures in a specific transportation corridor.
Instead, the rational behind these guidelines is that compensation should be linked to the type of
loss (monetary or otherwise) incurred by a particular group. Since the biggest loss to motorists
as a result of road pricing is a monetary loss, categories (1) and (2) are monetary transfers and can
thus be understood as ‘linked compensation’ (Small 1992b, 366). Motorists who switch to less
convenient routes or modes of transport as a result of road pricing receive linked compensation in
the form of improvements to these alternate routes or modes (Small 1992b, 366). Of course, the success of this plan hinges on the ability of planners to target reimbursements and expenditures in such a way so as to benefit the appropriate groups.

These guidelines for revenue expenditure address some of the objections to road pricing raised at the beginning of this chapter. Equity concerns can be addressed by reducing or eliminating regressive forms of vehicle taxation and improving transportation services in lower income areas. Regressive taxes that could be reduced include fuel taxes and special levies currently used to fund transit services in some metropolitan areas. Fuel taxes are regressive since automobile ownership and fuel consumption rise less than proportionately with income (Small 1992b, 367). Furthermore, higher income drivers tend to own newer, more fuel efficient cars, further aggravating the regressiveness of fuel taxation.\textsuperscript{9}

Opposition to road pricing based on fears that it will harm the economy can be reduced by pointing out the high costs of traffic congestion.\textsuperscript{10} Reduced congestion levels will produce substantial savings for business, benefiting the overall economy. The use of road pricing revenues to improve transportation linkages into and within the tolled area will further reduce congestion levels and increase the area's competitiveness. If the imposition of road charges and the use of road pricing revenues can effect a visible reduction in congestion, opposition based on fears that road pricing harms the economy will be diminished.

\textsuperscript{9}This is partially offset by the fact that higher income people tend to drive larger vehicles.

\textsuperscript{10}In Metropolitan Toronto alone, business organizations estimate that traffic congestion costs about $2 billion annually (Greenspon 01/08/94, A4).
Those who oppose road pricing as another form of taxation will find comfort in relief from general taxes currently used to fund transportation services as well as reduced vehicle taxes and fees. It is important that the government establish a clear link between road pricing revenues and reduced taxes in order to satisfy such critics.

**F: MODELS FOR IMPLEMENTING ROAD PRICING**

Successful implementation of a road pricing strategy is heavily dependent on how road pricing is introduced to the community. May (1992) identifies five alternate models on which to base the choice of implementation strategies (May 1992, 329-30).

The first approach is to include road pricing as part of an overall transportation policy review and seek public approval for that policy (May 1992, 329). This approach has the advantage of allowing the government to introduce complementary policy changes which will enhance the effectiveness of road pricing. Furthermore, surveys show that support for road pricing is much higher when it is presented as part of a comprehensive package with revenues allocated to improving alternate travel modes (Jones 1991, 195). In Singapore, where such a policy led approach was adopted, the introduction of road pricing was accompanied by improvements to public transit, changes in taxi fee schedules to encourage the pick up of passengers at the airport and in the restricted central area, higher vehicle taxes in the form of increased import duties, registration fees, and road taxes, and higher parking charges (Pendakur 1987, 209-11). Singaporeans, more so than their counterparts in western nations, tend to believe that the government acts in the general social interest, and hence have accepted the rules and costs of the ALS as part of the government’s transportation reforms (Morrison 1986, 94). Despite surveys
indicating the public’s preference for a package approach (Jones 1991; Jones and Harvey 1991), it remains unclear how accepting citizens of the more liberal western democracies would be of such rules and costs.\textsuperscript{11}

A second strategy is to develop the complex technology required to implement a highly flexible road pricing scheme and then to try and sell the scheme to the general public (May 1992, 329). Such an approach typifies the bias exhibited by many transport professionals towards economic and technical issues to the detriment of political concerns (see introduction to this chapter). This was the strategy adopted in Hong Kong where the Secretary of Transport Allan Scott announced in March 1983 that “the Hong Kong Government would be the first in the world to commit itself to testing the technical, economic and administrative viability of electronic road pricing (ERP)” (Hau 1990, 203). Ultimately, the ERP scheme was abandoned in 1985 because of political opposition based on concerns for privacy and road pricing’s distributional effects, public doubts about the government’s commitment to lower vehicle licence and registration fees, and a number of external factors that resulted in improved traffic speeds during the early 1980s (Hau 1990, 207, 210-11).\textsuperscript{12} A danger inherent in this approach is that a lot of time, money, and effort can be spent developing the charging system only to find that public support for the idea has evaporated (May 1992, 329).

\textsuperscript{11}For example, this approach has been used in an attempt to implement road pricing in the Randstad region of the Netherlands and in Stockholm, Sweden. In both cases, public opposition has led to substantial delays in implementation (May 1992, 329).

\textsuperscript{12}See Appendix 3 for a more detailed discussion of Hong Kong’s electronic road pricing experiment.
A third approach, which is politically acceptable but compromises the economic foundation of road pricing, is to present road charges as a means of financing transport infrastructure. This approach was used in Norway, where tolls have been introduced as a means of raising money for transportation projects. However, if the goals of road pricing are congestion reduction and environmental improvement, such an approach is difficult to justify (May 1992, 330).

A fourth strategy, popular in the United States, is demonstration projects (May 1992, 330). Demonstration projects are attractive because they allow analysts to observe behavioral responses to alternative road pricing structures and levels. This information will help transportation planners determine the appropriate road charge and pricing structure before road pricing is implemented on a system-wide basis (Poole 1992, 385). Demonstration projects also have the advantage of being incremental in nature. The pricing structures, technology, billing procedures, and other details which are difficult to plan in advance can be adjusted relatively painlessly. Politically, demonstration projects can be a powerful symbol of the advantages of road pricing if congestion on the demonstration facility is noticeably lower than on other facilities where access is free (Small 1992a, 289). The drawback of demonstration projects is that the results achieved may not be applicable throughout the region. This caveat is reinforced by the fact that demonstration projects will generally be located on highways that serve above average income residents, since it is in these areas that the greatest support for road pricing is likely to exist.

The final strategy is the analysis led approach. Under this strategy, a comprehensive study of all relevant issues and tradeoffs is made and an analytical programme is developed to answer them (May 1992, 330). Such an approach helps to ensure that political, economic, and technical issues
are considered at each stage of system development. Current planning efforts in London provide an example of the comprehensive approach. A three year study by the Department of Transport will examine the effects of a broad range of pricing options and policy scenarios on transport, the environment, the economy, equity, and the technological and administrative requirements of a pricing system (May 1992, 330). The study will regularly monitor public attitudes and reactions to a variety of pricing scenarios (May 1992, 330). This approach has the advantage that all factors (including public acceptability) are incorporated into the design stage of the system. Public objectives can be developed concurrently with technical and administrative requirements. The drawback of such an approach is that it is very time consuming as it involves the participation of a large number of groups, many of whom may have conflicting objectives. Without a firm timetable, the danger exists that important decisions will be indefinitely delayed and the whole process may unravel.

**G: CONCLUSION**

This chapter has reviewed the political forces likely to shape public debate about road pricing. Experience in other cities has shown that the major barrier to road pricing is political opposition; technological limitation, to which much time has been devoted, is not the determining factor in the success of a road pricing scheme.\(^{13}\)

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\(^{13}\)Singapore’s successful implementation of road charges around the central area requires motorists to display a simple paper permit to enter the restricted zone. Hong Kong failed to implement road pricing in 1985 because of political opposition, despite the impressive technical standards attained during a twenty-one month trial project.
Overcoming political resistance to road pricing will require that future proposals explicitly incorporate provisions to make road pricing more politically palatable. Based on research in this chapter, the following criteria emerge as essential to public acceptability:

- Road pricing should be perceived as fair in terms of its distributional effects on different income groups and geographic locations within the region.
- Road pricing should be designed to appeal to as many different interest groups and stakeholders as possible.
- Wherever possible, viable alternative travel modes should be available to motorists who wish to avoid paying the toll.
- Electronic toll collection systems should protect the privacy of users.
- Road pricing should be presented as a means of making more efficient use of road resources rather than as a form of taxation.
- Road pricing revenues should be linked to particular expenditure or tax reduction schemes, so that road pricing is not viewed as simply another tax.

These criteria, together with the conceptual basis for calculating road charges presented in Chapter 2, provide a framework for making the tough decisions involved in designing a road pricing system. Clearly, no single design will be appropriate for all regions. When considering road charges, each region must select among a number of design options based on the region’s transportation network, land use patterns, political structure, public attitudes, and anticipated population growth and transportation needs. In order to develop a road pricing strategy for Greater Vancouver, the next chapter examines the physical, demographic, and political factors which affect transport in the region.
CHAPTER 4
TRANSPORTATION IN GREATER VANCOUVER

A: INTRODUCTION

Traffic congestion and environmental pollution caused by automobiles are critical issues facing the Greater Vancouver region.\textsuperscript{1} In response to these issues, various transportation demand management (TDM) measures have been proposed and the region is beginning to debate the merits and drawbacks of alternate proposals. Discussions about TDM have, thus far, centred on the ‘carrot’ methods such as high occupancy vehicle (HOV) lanes, improved transit services, and promotion of telecommuting; the more onerous ‘sticks’ such as road pricing have received only limited consideration. This reluctance to consider road pricing measures to control traffic should not be taken as a sign of public satisfaction with the region’s transportation system. A 1993 survey found that a majority (60 percent) of respondents rated the Lower Mainland’s transportation system as only fair or poor, with congestion ranking as the number one transportation problem (TRANSPORT 2021 1993e, 6).

The purpose of this chapter is to describe those aspects of planning and transportation in Greater Vancouver which are relevant to the introduction of road pricing. Specifically, these include the political structure of decision making in the region, the region’s existing transportation network, and trends in travel patterns. The chapter concludes with a discussion of local public attitudes towards road pricing as a transportation demand management tool.

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\textsuperscript{1}Greater Vancouver is also referred to as the Lower Mainland.
B:  GOVERNMENT STRUCTURE AND TRANSPORT PLANNING

Responsibilities for transportation planning in Greater Vancouver are fragmented among the province and the numerous local governments of the region. This fragmentation exists along three lines: (1) geographic boundaries (fragmentation between municipalities); (2) transport mode or roadway category (fragmentation between the province and the municipalities); and (3) fragmentation between transport planning and land use control. This fragmentation of responsibilities arises, in part, from the structure of local government in British Columbia.

1:  The Legal Context of Local Government in British Columbia

Local governments in Canada have no statutory power under the Canadian constitution (Young 1993). Local governments are established by provincial statutes that set legal limits on their internal and external powers. In British Columbia, there are two acts which govern municipalities: the Vancouver Charter governs the City of Vancouver and the Municipal Act governs all other municipalities in the province (Young 1993). In addition to establishing municipal governments in incorporated areas,2 the British Columbia government has divided the province into twenty-eight Regional Districts, encompassing both incorporated and unincorporated areas. The Regional Districts have many of the same powers as municipalities with respect to the unincorporated areas; however, their region wide powers are limited to those powers which the member municipalities have chosen to delegate to them (Young 1993).

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2 Incorporated areas are those areas incorporated into a city, town, district, or village.
Chapter 4: Transportation in Greater Vancouver

2: Government in Greater Vancouver

The Vancouver Census Metropolitan Area (CMA) is made up of eleven cities, six districts, three villages, and three unincorporated electoral areas (see map 1). The City of Vancouver is the dominant municipality in the region, both in terms of population and employment (see table 1), although its relative importance is declining.

The Greater Vancouver Regional District (GVRD) encompasses all of the municipalities and unincorporated areas of the Vancouver CMA, with the exception of Maple Ridge and Pitt Meadows, which are part of the Dewdney - Alouette Regional District. The GVRD board is comprised of indirectly elected members from the municipalities and directly elected representatives from the unincorporated areas. The number of representatives from each municipality is based on population size and the number of votes that each representative may cast is determined according to a formula which varies depending on the issue under consideration (Young 1993). The relatively large population of the City of Vancouver has caused some concern among smaller municipalities of the potential for the interests of Vancouver to dominate the GVRD board (Heaver and Henriksson 1991, 258).

Since 1983, when the Social Credit Government of British Columbia stripped the GVRD of its regional planning powers, the GVRD has had to rely on the cooperation of member municipalities to fulfil its regional planning role. This lack of jurisdictional power over regional planning has meant that the GVRD has taken on more of an advisory and information gathering role with respect to transportation and land use issues (Forum for Planning Action 1991, 4). The GVRD can exert ‘peer’ pressure on member municipalities to adopt and implement a regional plan, but in the
Table 1: Population and Employment in the Vancouver CMA

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<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Burnaby</td>
<td>158,858</td>
<td>9.91</td>
</tr>
<tr>
<td>Coquitlam</td>
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</tr>
<tr>
<td>Delta</td>
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</tr>
<tr>
<td>Langley (City and Township)</td>
<td>85,805</td>
<td>5.94</td>
</tr>
<tr>
<td>Maple Ridge</td>
<td>48,422</td>
<td>3.35</td>
</tr>
<tr>
<td>New Westminster</td>
<td>43,585</td>
<td>2.72</td>
</tr>
<tr>
<td>North Vancouver (City and District)</td>
<td>113,593</td>
<td>7.86</td>
</tr>
<tr>
<td>Pitt Meadows</td>
<td>11,147</td>
<td>0.77</td>
</tr>
<tr>
<td>Port Coquitlam</td>
<td>36,773</td>
<td>2.55</td>
</tr>
<tr>
<td>Port Moody</td>
<td>17,708</td>
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</tr>
<tr>
<td>Richmond</td>
<td>126,624</td>
<td>8.77</td>
</tr>
<tr>
<td>Vancouver/University Endowment Lands</td>
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<td>32.98</td>
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<tr>
<td>West Vancouver</td>
<td>38,783</td>
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<tr>
<td>White Rock</td>
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</tr>
<tr>
<td>Indian Reserves</td>
<td>5,222</td>
<td>0.36</td>
</tr>
<tr>
<td>Other</td>
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<tr>
<td><strong>Vancouver CMA</strong></td>
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<td>100</td>
</tr>
</tbody>
</table>

(Source: GVRD 1993b, 42, 51)
final analysis, individual municipalities are under no obligation to accept the GVRD’s recommendations.

3: Provincial and Local Responsibilities for Transport

In addition to being fragmented by municipal borders, transportation planning in the Vancouver CMA is also fragmented between the provincial and local governments. As the division of responsibility differs between roads and public transport, these two travel modes are considered separately.

a. Private Road Transport

An important difference between the Municipal Act and the Vancouver Charter is its treatment of roads and highways. Under the Vancouver Charter, the City of Vancouver is “responsible for the planning, funding and operation of all roads [within its borders]” (Heaver and Henriksson 1991, 257). The province has no jurisdiction over any roads within the City of Vancouver, with the exception of provincially controlled bridges that end at the city’s border. The city is responsible for funding all improvements to its road system, although the province has provided assistance for some specific projects such as bridges (Heaver and Henriksson 1991, 257).

The division of provincial and municipal responsibilities for roads and highways outside of Vancouver is quite complex. The province maintains complete responsibility for the funding, operation, and policy decisions regarding primary arterial highways (Rayner 1993). The capital

3 Regulation governing responsibilities for roads and highways is also contained in the Highway Act.
costs of secondary arterial roads are shared evenly between the province and the municipality, while maintenance costs are shared 40 percent provincial, 60 percent municipal (Heaver and Henriksson 1991, 257). Policy decisions regarding secondary arterial roads are made jointly by the province and the municipality. Responsibility for funding and policy control over all municipal roads lies solely with the individual municipalities. Municipalities may, however, apply for funding assistance from the provincial government for roads which conform to the province’s Major Road Network Plan. Thus, through its funding resources, the province can influence policy decisions regarding the municipal road network (Rayner 1993).

b. Public Transportation

Public transit throughout British Columbia is the responsibility of the Crown corporation BC Transit (Heaver and Henriksson 1991, 260). In the Vancouver region, transit is provided by BC Transit in partnership with the Vancouver Regional Transit Commission (VRTC), a local body comprised of elected representatives from the municipalities in the region (Leicester 1991, 1). The VRTC has the responsibility to “prepare plans and, consistent with the operating and capital budgets set by the authority [BC Transit], set fares and determine service and performance standards” (BC Transit Act, Sect. 18(7) quoted in GVRD 1991, 11). The VRTC is prohibited from initiating expenditures or establishing budgets without the approval of BC Transit (GVRD 1991, 11). Hence, while local governments have some influence over transit issues through their

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4In order to receive funding assistance, the municipality must submit a major street plan which is agreeable to the province. The province is primarily interested in keeping local traffic off provincial highways (Rayner 1993).
participation in the VRTC, the province retains ultimate control over transit decisions through BC Transit.

4: Responsibility for Land Use Control

Through the Vancouver Charter and Municipal Act, the provincial government has delegated responsibility for land use control to the local level of government. Thus, within the Vancouver CMA, all land use decisions are made by the individual municipalities, even though such decisions may have transportation and other consequences that extend beyond the municipal borders. The only statutory regional planning requirement in British Columbia is that prior to adopting an Official Community Plan (OCP), municipalities must refer the OCP to adjoining municipalities for comment. The municipality is under no obligation, however, to act upon the recommendations of surrounding municipalities (Young 1993).

C: The Transportation Network in Greater Vancouver

1: Geographical Constraints

The geography of British Columbia's lower mainland has shaped the development pattern and transportation network of the region (see map 1). Downtown Vancouver, the focus of business and cultural activity, is located on a peninsula with Burrard Inlet to the north and False Creek to the south. Urban growth in the region is restricted by the mountains located north of Burrard Inlet, but the Fraser Valley to the south provides a substantial land mass for urban development (Heaver and Henriksson 1991, 255). The limited number of crossings over the Burrard Inlet and Fraser River act as choke points for transportation in the region and serve to meter traffic volumes.
entering the Burrard Peninsula. While congestion problems are not limited to the water crossings, the bridges and tunnels provide an attractive starting point for a road pricing scheme.

The geography of the region also limits the capacity of the natural environment to absorb pollutants released into the atmosphere. The mountains to the north tend to trap pollution in the Fraser Valley and thus, if increased population is not accompanied by a reduction in automobile dependence, air pollution has the potential to become a major problem in the region. Furthermore, the region’s many view corridors tend to increase peoples’ awareness of air pollution.

2: The Existing Road and Highway Network

A notable characteristic of the road system in Greater Vancouver is the relative lack of freeways. Moderate sized freeways do exist in the suburban areas, but do not extend into the City of Vancouver proper. This can be partially attributed to the unwillingness of the provincial government to fund freeways in Vancouver in 1950 (Heaver and Henriksson 1991, 257) as well as to “the freeway fights of the 1960s, when public opposition defeated plans to pave downtown neighbourhoods and span Burrard Inlet with a third bridge to the North Shore” (Wilson 1992, A6). Of particular significance was “the 1967 ‘Great Freeway Debate,’ in which a major east-west freeway planned to slice through the heart of Chinatown was defeated by public outcry” (Seelig and Artibise 1991, 59). Map 2 shows the primary arterial road and highway network in the Vancouver CMA, as well as the existing rapid transit route.
3: Public Transit in the Region

As discussed above, public transit in Vancouver is provided by the provincial Crown corporation BC Transit. The transit system is anchored by Skytrain, an Advanced Light Rail Transit system which runs from downtown Vancouver through Burnaby Metrotown to North Surrey (see map 2). There are plans to build additional ALRT lines in the region, although no firm commitments have been made. A commuter rail system between downtown Vancouver and the northeast sector is also under consideration.

The Skytrain system is complemented by two catamaran ferries which provide service from Waterfront Station in downtown Vancouver to Lonsdale Quay in North Vancouver (see map 2), and a comprehensive bus system which services over 1,480 square kilometres, the largest service area of any transit system in Canada (GVRD 1991, 33). Compared with other North American cities of similar size, transit service in Greater Vancouver is generally considered to be quite good, with 87 percent of Lower Mainland residents living within 400 meters of a bus route (TRANSPORT 2021 1993a, 44).5

D: Population Trends and Travel Patterns

1: Population Trends

Greater Vancouver is one of the fastest growing metropolitan areas in North America. The Census Metropolitan Area population increased from 1.27 million in 1981 to 1.60 million in 1991, a 26 percent increase in ten years (GVRD 1993b, 30). In general (except for Richmond), the rate of

5Based on 1991 statistics.
population growth was greatest in areas farthest away from the urban core, resulting in an increasingly dispersed settlement pattern (GVRD 1993a, 7). Urban sprawl is generally occurring in a southeastwardly direction (GVRD 1993a, 7). Based on current trends, it is estimated that the region’s population will reach 3 million by the year 2021 (GVRD 1993c, 14).

2: Travel Volumes

Partially as a result of smaller household size, decentralized development, and a relatively buoyant economy, the number of trips in the region is rising faster than increases in the population. Between 1985 and 1992, the number of trips during the morning peak-period (6 a.m. to 9 a.m.) increased by 37 percent, while the population grew by 21 percent (TRANSPORT 2021 1993a, 9). As a result, the trip rate (number of daily trips per person) increased from 0.51 to 0.57, an 11.8 percent increase (GVRD 1993a, 14). The 32 percent increase in the number of vehicles insured for commuting to work during this period was also greater than the increase in the region’s population (GVRD 1993a, 16).

3: Changes in Travel Patterns

The traditional assumption of a suburb to downtown commuting pattern is becoming less and less appropriate for the Vancouver region. The fastest growing category of trips are those that originate in and are destined for the suburbs, while the proportion of trips ending in the City of Vancouver is declining (see figure 3). Due to multiple origins and destinations, suburb to suburb commutes are very difficult to serve by public transit. The changing commuting patterns of the region have important implications for road pricing; an effective road pricing strategy should target suburb to suburb as well as suburb to city commutes.
Chapter 4: Transportation in Greater Vancouver

Figure 3: Sub-regional Commuting Patterns 1985-92

![Diagram showing sub-regional commuting patterns for 1985 and 1992. The diagram is color-coded to represent different travel patterns. The data shows a decrease in Suburb-Suburb travel and an increase in Vancouver-Suburb and Suburb-Vancouver travel. Source: GVRD 1993a, 27]

Figure 4: Morning Peak Period Mode Share 1985-92

![Diagram showing mode shares for the morning peak period in 1985 and 1992. The data shows a decrease in auto passenger and auto driver modes and an increase in bicycle & other, walk, and transit modes. Source: GVRD 1993a, 17]

Figure 5: Work Travel Characteristics 1985-92

![Bar chart showing work travel characteristics in 1985 and 1992. The chart shows changes in distance, trip time, and trip speed. Source: GVRD 1993a, 28]
4: Trends in the Mode of Travel

Figure 4 illustrates that despite heavy investments in public transit associated with the construction of Skytrain in 1985, transit’s mode share in the region fell from 11.2 percent in 1985 to 9.9 percent in 1992. Average vehicle occupancy also fell from 1.31 to 1.29 persons per vehicle. This resulted from an increase in the proportion of auto drivers from 54.3 percent of commuters in 1985 to 56.6 percent in 1992 (see figure 4). Lower vehicle occupancy and reduced transit mode share can be partially attributed to the increasingly dispersed settlement pattern described above.

5: Traffic Conditions

Figure 5 illustrates that traffic conditions during the morning peak-period (6 a.m. to 9 a.m.) are deteriorating. Between 1985 and 1992, the average distance of a morning commute to work increased by 12 percent (from 12.5 to 14.0 kilometres) while the average length of time spent commuting increased by 20 percent (from 20 to 24 minutes). The 7 percent reduction in average speed for morning peak-period work trips together with the fact that total travel time increased faster than distance suggest that congestion in the region is getting worse (GVRD 1993a, 27-28).

E: Public Attitudes Towards Road Pricing

As part of the TRANSPORT 2021 initiative, the GVRD and the Province of British Columbia have commissioned two studies investigating public attitudes towards transportation demand management. The first study, A Qualitative Research Study on Transportation Demand Management Measures (TRANSPORT 2021 1993b) summarizes the information gathered at two focus group sessions held in Vancouver on March 9, 1993 by Viewpoints Research, a Vancouver public opinion research firm. The second study, Public Opinion Surveys on Transportation
Demand Management in Greater Vancouver (TRANSPORT 2021 1993e) presents the results of a random telephone survey of 1200 people conducted by Viewpoints Research between April 22 and April 30, 1993. The principle findings of these studies regarding public attitudes towards road pricing are summarized below.

When presented with road pricing as means of managing transportation demand, focus group participants were "resigned to the fact that road tolls would eventually be a fact of life in the Lower Mainland and most saw the wisdom of a user pay approach" (TRANSPORT 2021 1993b, 8). Concerns about road pricing included: (1) how the money collected would be spent; (2) the effect of road pricing on downtown businesses; and (3) the logistics of toll collection (TRANSPORT 2021 1993b, 8).

The telephone survey of TDM options provides a more detailed account of public opinion towards road pricing and transportation issues. Table 2 illustrates that a majority of respondents felt that the prevalence of single occupancy vehicles (SOVs) was one of the biggest problems facing the region’s transportation system. Three-quarters of respondents agreed that strong measures should be taken to discourage people from driving alone to work; only one-third of respondents felt that building more roads was a good way to solve the region’s congestion problems. Furthermore, 79 percent of respondents agreed that “public transit and carpooling should be made more convenient and attractive rather than upgrading the roads” (TRANSPORT 2021 1993e, 8).

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6This paper also summarizes the results of a mail back survey which was sent to 15,000 households as part of the bulletin ‘Choices.’ The results of the mail back survey are not included in this thesis because the self-selected sample is not representative of the region.
Table 2: Public Perception of Transportation Problems

<table>
<thead>
<tr>
<th>Statement</th>
<th>Agree (%)</th>
<th>Disagree (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation in the Lower Mainland is not a major problem right now.</td>
<td>21</td>
<td>78</td>
</tr>
<tr>
<td>A good way to solve traffic congestion in Greater Vancouver would be to build more roads.</td>
<td>32</td>
<td>66</td>
</tr>
<tr>
<td>One of the biggest problems facing our transportation system is the large number of people who drive alone in their cars to work.</td>
<td>88</td>
<td>11</td>
</tr>
<tr>
<td>The Vancouver region needs to implement some strong measures right now to discourage people from driving alone in their cars to work.</td>
<td>76</td>
<td>22</td>
</tr>
<tr>
<td>People will use their cars less only if they have to pay progressively more for that privilege.</td>
<td>46</td>
<td>52</td>
</tr>
</tbody>
</table>

(Source: TRANSPORT 2021 1993e, 7)

It is interesting to note that despite these opinions, all toll options presented were rated as unacceptable by respondents (see table 3). Table 3 confirms that public acceptability of road pricing decreases as the toll charged increases. A $1 toll on all bridges in the Greater Vancouver area (except those crossing False Creek) was acceptable to one-third of respondents and less than half of the respondents rated such a scenario as unacceptable. When the toll was raised to $4, an overwhelming majority of respondents (90 percent) found it unacceptable.

The study grouped respondents into three regions: (1) south of the Fraser River; (2) north of the Fraser; and (3) residents of the City of Vancouver. Regional differences in the acceptability of bridge tolls were most pronounced for the $2 alternative. Residents south of the Fraser River were
Table 3: Public Reaction to Alternate Toll Options

<table>
<thead>
<tr>
<th>Statement</th>
<th>Unacceptable (%)</th>
<th>Neutral (%)</th>
<th>Acceptable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charging a one dollar toll during peak hours and a lesser toll during off-peak hours on all bridges in the Greater Vancouver area except those crossing False Creek.</td>
<td>51</td>
<td>14</td>
<td>34</td>
</tr>
<tr>
<td>Charging a two dollar toll during peak hours and a lesser toll during off-peak hours on all bridges in the Greater Vancouver area except those crossing False Creek.</td>
<td>70</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>Charging a four dollar toll during peak hours and a lesser toll during off-peak hours on all bridges in the Greater Vancouver area except those crossing False Creek.</td>
<td>87</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Collecting tolls on roads in general in the Greater Vancouver area during peak hours and a lesser toll during off-peak hours.</td>
<td>75</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

(Source: TRANSPORT 2021b 1993, 7)

most likely to rate a $2 peak-period bridge toll as unacceptable (75 percent), followed by residents north of the Fraser (71 percent). Vancouver residents were the least opposed to a $2 peak-period bridge toll (62 percent), presumably because only 27 percent of such residents crossed a major bridge (excluding those over False Creek) to get to work or school (TRANSPORT 2021 1993e, 12, 17).

When given the choice between tolls and additional gasoline taxes as a means for users to pay for maintaining and improving the transportation network, 47 percent of respondents preferred road and bridge tolls while 41 percent preferred increasing gasoline taxes (TRANSPORT 2021 1993e,
14). Twelve percent of respondents would not give an answer indicating that these respondents were either neutral or did not like either option. Thus, the results do not indicate a clear preference for one option over another (TRANSPORT 2021 1993e, 14).

The above research indicates that while respondents do not view road building as the answer to the region’s transportation problems, they are not yet ready to embrace road pricing as a solution either. However, public opinion does appear to favour the transportation demand management approach over more traditional supply-side remedies. This is a positive sign that effective transportation planning in the region can yet be achieved. As one of the more onerous TDM methods, road pricing received only limited support from survey respondents. Opposition to road pricing may be partially explained by a lack of understanding of the objectives of road pricing and by a lack of details available to respondents regarding the precise design of the road pricing scheme under discussion. Indeed, a system designed with public acceptability in mind may prove to be less unpopular than the survey results might indicate.

**CONCLUSION**

This chapter has outlined those features of Greater Vancouver’s transportation network which are most relevant to the introduction of road pricing. These features can be grouped according to their effect on the success of a road pricing policy. Vancouver’s geography, deteriorating traffic, high population growth rate, and concern for issues of livability and the environment increase the attractiveness and likely success of road pricing. The lack of a strong regional government is a hinderance to road pricing’s successful implementation. Dispersed development trends increase the justification for road pricing, but make it harder to implement. Finally, the fact that traffic
congestion in Greater Vancouver has not yet deteriorated to the level common in larger North American cities, reduces the sense of urgency to tackle the region’s growing transportation problems.

Nonetheless, the region’s transportation problems should be confronted. If the Vancouver area is to retain its current level of livability, policies should be implemented to curb the region’s growing reliance on the private automobile. While road pricing is not the only means of influencing travel behaviour, it is a powerful tool that deserves serious consideration. The next chapter will explore the question of how road pricing should be integrated into Greater Vancouver’s transportation network.
CHAPTER 5

A ROAD PRICING STRATEGY FOR GREATER VANCOUVER

A: INTRODUCTION

Greater Vancouver is beginning to discuss the idea of charging motorists to cross major bridges and tunnels in the region. The imposition of charges on existing roadways would represent a fundamental shift in transport policy for a region that does not currently have any toll facilities. Charging motorists for road space offers exciting possibilities for improving the efficiency and performance of the transportation system as well as reducing the environmental effects of the automobile. At this early stage, it is unclear whether discussions about tolling will lead to a comprehensive road pricing system, road charges designed simply to raise revenues, or whether the idea of charging for road space will be rejected entirely.

The purpose of this chapter is to advance ideas about how road pricing should be implemented in Greater Vancouver. Specifically, the chapter seeks to answer some fundamental questions concerning the design of a road pricing scheme, the appropriate method of implementation, and the integration of road pricing with land development and transportation policy. While the recommendations of this chapter are necessarily subjective, they are based on the economic logic of road pricing developed in Chapter 2, the political issues raised in Chapter 3, and the existing situation in Greater Vancouver outlined in Chapter 4.
B: **WHY ROAD PRICING?**

There are three principle reasons why road pricing should be implemented in Greater Vancouver: (1) current transportation policies are leading the region away, rather than towards, its stated goals; (2) road pricing is the only transportation demand management (TDM) method which can significantly affect travel behaviour; and (3) road pricing will help to restore the efficiency between transport and land prices in the region.

1: **The Failure of Current Policies**

The Greater Vancouver Regional District’s *Creating Our Future* programme established a vision for Greater Vancouver as “a metropolitan region that combines economic vitality with the highest standards of livability and environmental quality” (GVRD 1993c, 2). The vision, which was originally adopted by the GVRD in 1990 and updated in 1993, calls for increased reliance on walking, cycling, and transit as well as the containment of urban sprawl (GVRD 1993c, 3).

Current transportation and development trends, summarized in Chapter 4, are inconsistent with this vision. Automobile travel in the region is increasing while average vehicle occupancy and the mode share of transit is declining (see Chapter 4, figure 4). Population is increasing fastest in the outer suburbs resulting in southeastward urban sprawl. The current pattern of land development is very travel intensive and does not provide sufficient opportunities for walking, cycling, transit, or ride sharing as alternatives to the private automobile. Existing transportation policy has failed to reverse these trends; conversely, these trends “have been assisted by the existing transportation system, which has increased the accessibility among the various parts of the region over the past
30 years” (TRANSPORT 2021 1993a, 11). If Greater Vancouver is to achieve its stated goals, transportation policy will have to change.

Chapter 4 also illustrates that traffic conditions in Greater Vancouver are deteriorating. Average distance travelled and time taken to get to work are increasing while trip speeds are falling (see Chapter 4, figure 5). In the absence of a change in transportation policy, traffic conditions and congestion levels are likely to continue to get worse.

2: Road Pricing is More Effective than Other Policies

Chapter 1 of this thesis summarizes, at a general level, why road pricing is an effective response to the urban transportation problem. Fiscal and environmental constraints severely limit the prospects for increasing road capacity in the region. Furthermore, Downs’s Law (Downs 1962) illustrates why, even in the absence of such constraints, supply-side responses are likely to be ineffectual. Less onerous TDM methods, such as voluntary trip reduction programs, high occupancy vehicle (HOV) lanes, and further investments in public transit, are unlikely to produce significant changes in travel behaviour.

Vancouver has had direct experience with the inability of transit investment to affect travel patterns. In 1985, the region built its first rapid transit line, a state of the art light rail system connecting downtown Vancouver with Burnaby Metrotown and North Surrey. Despite significant investments associated with Skytrain’s construction, transit’s mode share has declined since 1985 (see Chapter 4, figure 4).
TRANSPORT 2021 recently completed a study of the effects of transportation demand management on automobile and transit use in the region. Although the effectiveness of alternate TDM methods is difficult to rank, the study generally showed “that the pricing TDM methods (parking charges, gas tax, CBD licensing fee and bridge tolls) and the mandatory employer trip-reduction program, as defined, have the largest estimated effect in reducing automobile use and increasing transit use” (TRANSPORT 2021 1993g, 76). Mandatory trip reduction programs, while effective, do not result in an efficient use of scarce resources and therefore impose far higher costs on society than do market-based strategies. Gasoline taxes are too blunt an instrument to effectively deal with the time and place specific costs of urban travel. Parking charges do not affect through traffic or motorists with access to private parking stalls. While the ability of alternate TDM methods to influence travel behaviour will only be known through implementation, a well designed system of road charges appears to offer many advantages over the other approaches.

3: The Efficiency Between Land and Transport Prices

The location decision of households involves a tradeoff between the costs of land and transportation (Hensher 1993, 3). If the costs of transportation are artificially low, households will tend to consume too much transportation and not enough land (in monetary not physical terms).

Transportation in Greater Vancouver is underpriced (TRANSPORT 2021 1993a, 23). A recent study of transportation costs in the Lower Mainland found that private motorists pay roughly 77 percent of the total costs of driving while transit riders pay about 63 percent of the costs of transit services (KPMG 1993, 29-30). Artificially low transportation prices have contributed to Greater
Vancouver's dispersed settlement pattern. Unless the price of transport is brought closer to its true cost, a majority of people will continue to find the benefits of larger, less expensive housing located in the outlying areas greater than the costs and inconvenience of travelling to and from dispersed employment and leisure activities (Hensher 1993, 3). Because road pricing is based on the premise that motorists should pay the marginal costs of travel, it provides an effective means of restoring the balance between transportation and housing prices.

As a rapidly growing region, the problem of artificially low transportation prices is particularly relevant to Greater Vancouver. Households base their location decisions on current and anticipated housing and transport costs. If such decisions are biased towards sprawling, travel intensive development on the urban fringe, the excess demands placed on the region's transportation system will be felt long into the future. The benefits of road pricing will be greatest where it can be used to effect a more efficient pattern of land development. Once travel intensive land patterns become established, the opportunity for influencing travel behaviour is severely constrained. Therefore, even though traffic congestion has not yet reached intolerable levels in Greater Vancouver, road pricing has an important role to play in shaping the region's development.

C: DESIGN ISSUES FOR ROAD PRICING

In formulating a road pricing strategy for Greater Vancouver, there are three important design questions to be considered: (1) What is the primary objective of road pricing? (2) How comprehensive should the system be? and (3) How should road pricing revenues be spent? In addressing these questions, this chapter attempts to strike a balance between economic efficiency
and political acceptability. Operational constraints and opportunities will also be used to select among competing choices.

1: The Objectives of Road Pricing

Road pricing can be viewed as a transportation demand management tool or as a means of raising revenue. While these two objectives are not mutually exclusive, the choice among them will have important implications for the design and economic benefits of road pricing.

Throughout this thesis, road pricing has been presented as a means of making more efficient use of the road network. Chapter 2 illustrates that in the absence of road charges, an inefficiently large number of trips are undertaken, resulting in excessive congestion and a loss of welfare to society. On a theoretical level, the objective of road pricing is clear: road pricing should be used to allocate scarce road capacity during periods of peak demand. In the Vancouver context, this would imply that road charges should be collected during the peak hours at all choke points in the region, where the demand for road space routinely exceeds the available supply.

As a transportation demand management tool, road pricing can also be used to achieve other objectives. The priority given to environmental protection in the Vancouver area makes reducing the environmental effects of motor vehicles an important secondary objective of road pricing. By reducing congestion, road pricing will bring about a reduction in the incidence of pollutants, such as carbon monoxide and noise, which are exacerbated at low speeds. In the short run, road pricing's effect on the incidence of other pollutants will depend on whether a significant number of peak-hour motorists choose to ride share or use public transit, rather than simply using their cars
outside of the peak period. If the environmental benefits of road pricing are to be fully realized, it is important that complementary policies be implemented to encourage the use of alternate travel modes. In the longer run, road pricing can be used to shape development patterns and metropolitan form. A more compact region will increase the opportunities for walking, cycling, and transit, and will thus have significant environmental benefits.

Road pricing also has powerful appeal as a source of government revenue. Given the current fiscal climate in Canada, governments at all levels are moving away from traditional methods of paying for infrastructure and are examining more creative approaches, such as user fees and private-public partnerships. In British Columbia, this trend has manifested itself through the formation of the Transportation Financing Authority, which is charged with examining alternate means of financing transportation investments in the province (TRANSPORT 2021 1993a, 45).

While it may be desirable for the government to retain some of the revenues from road pricing (to fund improved transit, for example), revenue generation should not be considered a primary objective. To do so would compromise the theoretical justification for implementing road pricing and would likely lead to a set of charges which are not based on marginal cost. Furthermore, if the government were to keep a large proportion of road pricing revenues, road pricing would be difficult to ‘sell’ to the public as a transportation demand management tool. In such cases, road pricing is likely to be correctly viewed as simply another form of taxation. While this may be acceptable on new facilities such as the proposed replacement of the Lions Gate Bridge, the public is unlikely to support such a scheme on existing facilities. Many of the bridges in Vancouver were originally paid for with tolls and the public would almost certainly be unwilling to ‘pay for them
again.' Therefore, for reasons of economic efficiency and political acceptability, revenue generation should not be considered a primary objective of road pricing.

2: Comprehensiveness of the Charging System

The second major design issue to be addressed is the comprehensiveness of the charging system. A comprehensive system where all major routes are tolled would be much more effective at achieving the objective of reducing traffic congestion than would a scheme which provided untolled alternates for motorists who wished to avoid the road charge.

Vancouver’s geography lends itself well to a comprehensive road pricing system. Tolls could easily be implemented on all of the bridges and tunnels that cross the Fraser River and Burrard Inlet. Together with other charging points located at strategic locations throughout the region, this would form a comprehensive network of road charges along most major routes.

A comprehensive system might be difficult to sell politically. Based on equity and fairness, the public is unlikely to support a scheme that does not provide an alternate ‘free’ route for motorists wishing to avoid the toll. Several groups, including the Canadian Automobile Association, the Better Roads Coalition, and the Ontario Trucking Association, have made their support for tolls on new roadways conditional upon a free alternate route being available (Better Roads Coalition 1992; Canadian Automobile Association 1993; Ontario Trucking Association 1993).

One solution that would overcome some of the objections to a comprehensive scheme would be to waive the toll for HOVs. While such a policy does not adhere to marginal cost pricing, it would
encourage ride sharing and would provide an alternate, toll free form of travel. Providing free access for HOVs would have important political benefits based on equity grounds. Furthermore, such a policy should appeal to the majority of Greater Vancouver residents who believe that SOV commuting is one of the biggest problems facing the region’s transportation system (see Chapter 4, table 2). Such a policy would also reinforce the message that the goal of road pricing is not to pay for infrastructure, by rather to make more efficient use of the road network.

3: The Use of Road Pricing Revenues

The use of revenues is crucial to public acceptance of road pricing. As discussed in Chapter 3, Small (1992b) recommends that revenues be allocated equally between reimbursements to drivers in general, reductions in general taxes, and expansion of transportation services. This recommendation will be used as a framework for analyzing the use of revenues from road pricing in Greater Vancouver.

In order to illustrate the use of revenues, a rough estimate of road pricing revenues is required. A more accurate estimate of revenues could be calculated once the number of charging points, user response, and exact road charge were determined. The estimate below is presented for discussion purposes only.

There are approximately 392,100 a.m. peak-period vehicle trips made in Greater Vancouver each weekday (TRANSPORT 2021 1993c, 47). Hence, it is estimated that there are about 494,046
morning and afternoon peak-period trips in the peak direction each day\textsuperscript{1} and approximately 128,451,960 peak-period direction trips per year.\textsuperscript{2} Assuming an average road charge of $1.75 per trip,\textsuperscript{3} and further assuming that 15 percent of trips would switch to transit or HOVs, total road pricing revenues in Greater Vancouver would be $191,072,291, or approximately $200 million. This estimate is consistent with a study done by DeCorla-Souza and Kane (US Department of Transport 1992, 12) of road pricing in a hypothetical urban area of 1.5 million inhabitants, which estimated revenues of US$685,000 ($913,333) per day or approximately $237 million per year (based on a five day work week). The $200 million estimate for road pricing revenues was also confirmed as being 'in the ball park' by Karoly Krajczar of the GVRD’s strategic planning department (Krajczar 02/25/94). Based on experience elsewhere, approximately 12 percent ($24 million) of road pricing revenues will be needed to cover operating expenses (Kanga 02/01/94), leaving net revenues from road pricing of about $176 million.

Current public expenditures on roads and transit in Greater Vancouver are approximately $630 million (including debt servicing costs for transit) while current revenues associated with roads and

\textsuperscript{1}\textsuperscript{1}This assumes that: (p.m. peak-period trip volume) = (1.1) * (a.m. peak-period trip volume) and that 60 percent of trips are made in the peak direction. These assumptions are the author’s estimates based on cordon counts for vehicles entering the City of Vancouver.

\textsuperscript{2}\textsuperscript{2}Based on 5 days per week and 52 weeks per year.

\textsuperscript{3}\textsuperscript{3}At an average trip distance to work of 14 kilometres, a $1.75 toll represents 12.5 cents per vehicle kilometre, which is consistent with the 15 cents (US) per vehicle mile (approximately 12.4 cents per kilometre) used by Kenneth Small in a hypothetical pricing scheme for Atlanta (US Department of Transportation 1992, 11) and slightly above the 12.6 cents (US) per vehicle mile (approximately 10.4 cents per vehicle kilometre) used by DeCorla-Souza and Kane in a study of road pricing in a hypothetical U.S. city (US Department of Transportation 1992, 12).
transit are about $530 million (TRANSPORT 2021 1993a, 48-49). 4 Given the significance of road pricing revenues compared with current transportation revenues and expenditures, the use of these revenues becomes all the more crucial.

Given that revenue generation is not a primary objective, it would be undesirable for the government to retain all of the revenues from road pricing. Furthermore, the public is unlikely to accept road pricing, unless revenues are used to offset other taxes or are dedicated to specific projects. The use of revenues was one of the concerns expressed by participants in a recent focus group session about applying TDM in Greater Vancouver (see Chapter 4, page 65). Following Small (1992b), the plan set out below is designed to appeal to as many different groups as possible, without compromising the economic principles on which road pricing is based.

Because road pricing will induce some motorists to switch to transit, there is a strong argument for using road pricing revenues to fund improvements to transit services. An estimate of the amount of revenue that should be diverted to transit can be derived by comparing the financial subsidy currently given to private and public transportation. A recent report on the costs of transport in Greater Vancouver (KPMG 1993) estimated that the total cost per kilometre of transit service in the urban a.m. peak is 71.7 cents while the cost per kilometre for private vehicles is 96.8 cents (KPMG 1993, iii). Based on an average trip length of 14 kilometres (KPMG 1993, iii), the cost per trip in the a.m. peak is $10.038 for transit and $13.552 for private vehicles. Transit is

4These figures exclude transportation related revenues and expenditures by the federal government.
estimated to be subsidized by 37 percent, of which 95 percent is a financial subsidy, while the subsidy to private vehicles is 23 percent, of which 40 percent is a financial subsidy (KPMG 1993, iv). Thus the financial subsidy to transit is approximately 35 percent of total costs and the financial subsidy to private vehicles is about 9 percent of total costs. Based on these estimates, the financial subsidy per transit trip is $3.51 and the financial subsidy per vehicle trip is $1.22. Hence, each motorist who switches to transit costs the government $2.29. If we assume that 10 percent of peak-hour motorists will switch to transit as a result of road pricing, approximately $30 million will be required just to maintain current service levels. An additional $30 million will be allocated to fund improvements in transit and HOV services. The $60 million allocated to transit and HOV services will provide people who wish to avoid the toll with additional transport options and will serve to mitigate the regressive nature of road pricing.

Road pricing revenues could also be used to offset the transit surtax currently charged on gasoline sold in the Lower Mainland (approximately $50 million) (TRANSPORT 2021 1993a, 49). This would offset some of the costs to motorists of road pricing. The replacement of a regressive fuel tax would also have distributional benefits.

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5 Subsidies are composed of financial and economic subsidies. Financial subsidies include such things as the costs of road construction and maintenance not covered from vehicle taxes and the operating costs of transit not covered from fares. Economic subsidies, also referred to as externalities, are nonfinancial costs and include air pollution, noise, and unaccounted accident expenses (KPMG 1993, iv).

6 This figure is based on the previous estimate that there are approximately 128,451,960 peak-period direction trips per year.
Replacement of the transit levy on electricity (approximately $10 million) (TRANSPORT 2021 1993a, 49) and a $30 million reduction in property taxes would benefit a broad cross section of society. In particular, this would generate support for road pricing among nonmotorists who would benefit from reduced taxes without incurring a financial loss due to road pricing.

The remaining $26 million could be used to encourage the development of affordable and higher density housing along major transit routes. This would increase the availability of low cost housing closer to the city centre and reduce the need for lower income residents to operate a motor vehicle. Increased densification could be viewed as the contribution made by the inner municipalities to help solve congestion and air pollution problems (the acceptance of road pricing being the contribution made by the outer municipalities). This would help reduce the perception of road pricing as a policy which benefits the inner areas at the expense of the outer municipalities.

D: IMPLEMENTATION ISSUES

1: Is a Regional Authority Necessary?

As discussed in Chapter 4, Greater Vancouver does not have a strong regional government. An important question to consider is whether road pricing can be successfully implemented in the absence of a strong regional presence. Downs (1992) suggests that a regional government is required in order to solve congestion problems:

Those [local] governments will never voluntarily agree on how to make certain hard choices that affect congestion levels. Rather, each will seek to maximize its own residents’ benefits and minimize their bearing of any social costs involved in cutting congestion. Hence the decisions necessary to reduce congestion effectively can only be made by one or more regional bodies with true authority and power not only over traffic flows but also over several other crucial elements.

(Downs 1992, 4)
The geographic structure of Greater Vancouver increases the need for a regional body. Because the Fraser River and Burrard Inlet help to define the political boundaries within the region, road pricing is likely to be viewed as benefiting the City of Vancouver and parts of Burnaby, at the expense of the outer municipalities. Support for this observation comes from the survey work summarized in Chapter 4, which found that residents south of the Fraser River were most opposed to bridge tolls while Vancouver residents were least opposed (see Chapter 4, page 67). In the absence of a regional authority, it will be difficult to get the outer municipalities to agree to implement road pricing. Furthermore, if road pricing is to result in a more compact metropolitan form, the inner municipalities must be willing to absorb more growth. Unless this is mandated by some form of regional authority, it is unclear how local governments will respond to regional pressures to densify on the one hand and pressure from their citizens to maintain low density single family neighbourhoods on the other. Transportation is a regional issue and the fundamental cause of traffic problems can only be solved by a regional authority (Seelig and Artibise 1991, 66).

Because the provincial government maintains responsibility for a majority of the major traffic arteries outside of the City of Vancouver proper, the province could impose road pricing on the region. In effect, the province could assume the role of a regional government, although such a philosophy is likely to be met with resistance from the public as well as from local politicians. A regional government, comprised of locally elected officials with real planning powers, would be in a better position to garner local support for road pricing as well as make the tough decisions required for road pricing to be implemented. Greater Vancouver currently lacks such a regional structure.
2: Implementing Road Pricing

The method chosen for implementing road pricing will have important ramifications for its political acceptability. Chapter 3 discussed five different implementation strategies: (1) including road pricing as part of an overall policy review; (2) developing road pricing technology in advance of a political consensus; (3) presenting road pricing as a means to pay for infrastructure; (4) demonstration projects; and (5) the analysis led approach. A recurring theme of this thesis has been that politics, not technology, represents the biggest barrier to implementing road pricing; therefore, the technology led approach is not considered suitable. Further, the discussion earlier in this chapter concluded that revenue generation should not be considered a primary objective of road pricing; thus, presenting road pricing as a means of paying for infrastructure is also inappropriate. Of the three remaining approaches, demonstration projects appear to offer the greatest potential for success, provided that they are accompanied by a clear plan to implement road pricing on a system-wide basis.

Demonstration projects have many advantages from the perspectives of both the road authority and public acceptability. For the road authority, demonstration projects provide the opportunity to learn more about driver response to road pricing (Poole 1992, 385). Because road pricing represents such a drastic shift in transport policy, this response is difficult to predict using existing modelling techniques. Demonstration projects would therefore be of great value in assisting the road authority to determine the appropriate price level and system design, prior to full scale implementation. Further, demonstration projects offer a less risky alternative to full scale implementation, both in terms of financial commitments and potential political backlash.
From the perspective of public acceptability, demonstration projects are particularly valuable in a region such as Greater Vancouver, which currently has no toll facilities. Much of the opposition to road pricing arises because people are not used to the idea of paying for road space. Public acceptance of peak-period parking differentials for both private and public facilities suggests that opposition to road pricing is based more on historical precedent than on a philosophical opposition to peak charges for automobile use. Demonstration projects are needed to break the seemingly illogical mind set that peak-period pricing of stationary vehicles is acceptable but such a pricing policy for moving vehicles is not. Demonstration projects would also help convince the public of the effectiveness of road pricing as a traffic management tool.

The most logical candidate for a road pricing demonstration project in Greater Vancouver is the Lions Gate Bridge. The bridge is near the end of its useful life and the region is currently discussing various replacement and rehabilitation options. There are a number of factors which make the Lions Gate ripe for a road pricing experiment. Because the bridge has a direct effect on Stanley Park, there is a lot of interest in ideas such as road pricing, which would reduce the bridge’s environmental effects. The bridge acts as a feeder for traffic into Vancouver’s West End, a high density residential neighbourhood located adjacent to the Central Business District (CBD). This politically influential residential area would likely support proposals such as road pricing, which would reduce the effects of traffic on the West End neighbourhood. The only traffic alternate to the Lions Gate, the Second Narrows Bridge, is located approximately 7.5 kilometres to the east and does not lead to the CBD. Since 85 percent of a.m. peak-period southbound traffic is destined for downtown Vancouver or Vancouver’s West side (Province of British Columbia 1993, E3), the majority of vehicles on the Lions Gate bridge have no traffic alternate. Transit
service to the North Shore is generally quite good, with SeaBus connecting directly to the Skytrain System. Thus, for most commuters crossing the Lions Gate, transit provides a reasonable alternative to driving. Finally, the bridge serves a relatively affluent area of the region\(^7\) and therefore objections based on equity are less of a concern with respect to Lions Gate than they might be in other areas.

A road pricing experiment would be more useful if implemented on the existing bridge than on a new structure. The benefits of road pricing may be difficult to demonstrate on a new bridge, if the capacity of the bridge is increased as a result of reconstruction. By implementing road pricing on the existing facility, valuable knowledge about driver response could be gained to help determine the appropriate size for the new or rehabilitated facility. While implementing an experimental road pricing system on the existing facility has many advantages, the set-up costs may prove prohibitive due to the existing bridge’s short remaining life. If a low cost toll collection system is adopted as a cost saving measure, this may not provide an adequate assessment of the benefits of road pricing or of driver response under a higher quality charging system. The feasibility of implementing road pricing on the existing bridge requires further engineering study.

A demonstration project on the Lions Gate Bridge will only be successful if it is accompanied by a credible plan to expand road pricing to other key facilities in the region. To minimize future opposition to system-wide implementation, this intention should be stated explicitly in the original plans. A clear timetable for implementing road pricing on a system-wide basis should be

\(^7\)The average 1990 income per taxfiler in North Vancouver was 9 percent above the average for the region while the income of West Vancouver residents was 73 percent above average (GVRD 1993b, 65).
established early in the process, to ensure that momentum is maintained. While public acceptance of a comprehensive road pricing scheme is far from assured, a well designed demonstration project on the Lions Gate Bridge will increase the likelihood of future success.

E: ROAD PRICING IN THE CONTEXT OF LAND USE AND TRANSPORTATION POLICY

1: Road Pricing and Land Use Policy

The containment of urban sprawl has been identified as a major regional objective (GVRD 1993c, 3). By raising the marginal costs of road travel, road pricing will help to discourage developments on the urban fringe. However, unless areas such as Vancouver, Burnaby, New Westminster, North Surrey, and North Delta are willing to accept increased densities, the goal of a more compact urban form is unlikely to be attained. If road pricing is to effect a significant change in settlement patterns, the availability of reasonably priced housing close to the urban centre must be increased. Given the rapid growth anticipated in the region, such housing can only be provided through significant densification. Road pricing and densification are complementary policies in the sense that without densification, road pricing will be unable to effect a more compact development pattern due to a lack of housing opportunities. Conversely, in the absence of road pricing, attempts to create a more densely populated region will continue to be constrained by artificially low transportation prices which encourage sprawling development. Only when both policies are working in tandem, can the goal of a more compact metropolitan form be attained.

2: Road Pricing and Transportation Policy

This thesis has argued that road pricing is one of the more effective transportation demand management tools. Nonetheless, road pricing will only be effective if it is part of an integrated
transportation policy designed to reduce dependence on private vehicles. An integrated policy would send a clear signal that the region intends to make more efficient use of its transport infrastructure.

a. Road Building

Road pricing will not eliminate the need for new road construction. Given Greater Vancouver’s rapidly growing population, road capacity will need to be expanded to maintain adequate service levels. However, the efficiencies in road use resulting from road pricing and other TDM measures should significantly reduce the amount of additional road space required. The effect of any decision to increase capacity, particularly limited access roadways, should consider the long term effects of this expansion on land use patterns.

b. Public Transit and HOV Facilities

Road pricing should be accompanied by improvements to transit service and HOV facilities in order to provide motorists with an attractive alternative to driving alone. This would increase the effectiveness of road pricing as a transportation demand management tool. While additional investment in transit will be required if road pricing is to significantly affect the mode split, short term service improvements could be attained through transit priority measures. Specific measures include dedicated bus lanes on congested streets, giving priority to transit vehicles at traffic lights, and giving buses priority over moving traffic when entering the roadway after leaving a bus stop. Similarly, HOVs should be given priority over single occupant vehicles. These measures would be relatively inexpensive to implement and could significantly reduce the travel time of transit riders and HOV commuters. Where implemented on congested streets, such measures would also
increase the capacity of the roadway (in terms of moving people, not vehicles). While capital intensive improvements in transit service should be introduced at the same time as road pricing in order to create a link between the two policies, HOV services and transit priority measures should be introduced immediately, to familiarize the public with transportation demand management concepts.

c. Pedestrian and Bicycle Facilities

Greater attention should be paid to pedestrians and cyclists in the design of the streetscape. Any reconstruction of roads associated with the implementation of road pricing should make provisions for cyclists. Additional facilities, such as lockers and showers, should be incorporated into new developments to further encourage commuter cycling. Increased densities and the more compact development pattern promoted by road pricing are consistent with a policy of encouraging walking and cycling as alternatives to driving and transit use.

F: Conclusion

The road pricing strategy outlined in this chapter is designed to appeal to the public, yet remain true to the economic principles on which road pricing is based. The strategy provides answers to some of the fundamental questions regarding the implementation of road pricing in Greater Vancouver. Based on this strategy, microlevel issues such as the precise location of charging points, the appropriate charging level, and the choice of road pricing technologies can be investigated.
The strategy is suboptimal based on both political acceptability and economic efficiency grounds. However, it is not designed to be optimal; it is designed to be realistic. If road pricing is to be successfully implemented, transportation professionals must recognize the political realities of democratic government and design road pricing schemes which politicians can accept. At the same time, politicians must act in the regional interest, even if it means making politically unpopular decisions. If the road pricing scheme presented in this thesis has struck an appropriate balance between these two forces, then it will have succeeded in bringing the benefits of road pricing closer to reality.
CHAPTER 6
CONCLUSION

A: SUMMARY

While far from universally accepted, transportation demand management (TDM) appears to be gaining legitimacy as a key element of transportation policy in Greater Vancouver. This apparent change in philosophy has been motivated by the realization that traditional approaches, which focus on expanding capacity to meet rising demand, are both ineffective and unsustainable. As one of the more innovative yet unpopular TDM measures, road pricing provides an important litmus test of the resolve of local politicians, transportation planners, and the general public to implement meaningful measures to control automobile use.

Successful implementation of road pricing will not be easy. Despite the theoretical soundness and economic benefits of road pricing outlined by this thesis, there remain many political obstacles to implementation. This thesis included a discussion of the political dynamics of road pricing so that these obstacles could be better understood and more easily overcome. Technical advances, described in Appendix 1, continue to increase the flexibility and reliability of electronic charging systems. The continuing convergence of these three forces -- economics, politics, and technology -- will be required if road pricing is to gain widespread acceptance.

This thesis has tried to develop a practical strategy to implement road pricing in Greater Vancouver. This task has been motivated by a desire to make more efficient use of the valuable resources devoted to urban transport. Based on research into the political considerations and
economic foundations behind road pricing, this thesis reaches the following conclusions about the appropriate design of road pricing in the Vancouver area:

- Road pricing should be used as a transportation demand management tool, not as a revenue generating device.
- Road pricing should be implemented as comprehensively as possible throughout the region.
- The province should create a regional transportation authority with real power over transportation and land use planning to implement road pricing and related policies.
- Road pricing revenues should be used to improve public transit, to offset the transit surtax currently charged on gasoline and electricity, to reduce property taxes, and to promote the construction of high density housing along major transit corridors.
- The region should implement road pricing on the Lions Gate Bridge as a demonstration project. This should be accompanied by a clear plan and timetable for implementing road pricing on a system-wide basis.
- Road pricing measures should be complemented by a land development policy designed to encourage densification in the inner municipalities and by other transportation demand management measures designed to reduce reliance on private motorized vehicles.

B: CLOSING COMMENTS

Current road pricing practices, or lack thereof, are so wasteful and inefficient that it is only a matter of time until comprehensive road pricing systems are implemented in numerous cities around the world. The urgency surrounding road pricing is directly related to congestion levels. Public frustration with intolerable traffic delays is making road pricing an increasingly attractive option for the world’s largest, most congested cities. For less congested cities such as Vancouver, the problem is somewhat less urgent, although no less important. Such cities should learn from the mistakes of their more congested counterparts, and should implement traffic restraint policies
such as road pricing before traffic conditions deteriorate to unbearable levels. By delaying adoption of such policies, local politicians and transportation planners are merely delaying the inevitable. Increased environmental awareness and a focus on economic efficiency continue to increase the justification for road pricing and related transportation demand management methods. It would appear that the time for road pricing has finally come.
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APPENDIX 1
ELECTRONIC ROAD PRICING TECHNOLOGIES

A: INTRODUCTION

There are five principle components of an electronic road pricing system (May 1993b, 22-23):¹

(1) an in-vehicle unit (IVU) which can communicate with the roadside to carry out transactions;
(2) a payment and accounting system which allows for charges to be levied and audited;
(3) a system for roadside communication;
(4) a means of detecting passing vehicles; and
(5) a system to detect noncompliant vehicles.

This appendix provides a summary of the available and developing technologies in each of these five areas.

B: IN-VEHICLE UNITS

1: Stickers

Stickers are the simplest form of an in-vehicle unit. Vehicles passing a cordon line are required to display a valid sticker, which is verified by a manual observer or video camera. The advantages of a sticker system are that it is easy to implement and inexpensive to equip occasional visitors. Its disadvantages are that the complexity of the charging system is extremely limited, the stickers

¹This Appendix draws heavily on work done for the London Congestion Charging project, as summarized by May (1993b).
are easy to forge, and the system is difficult to operate in high speed, multilane environments (May 1993b, 24-25).

2: **Read-only Tags**

Read-only tags contain a fixed identification code which is relayed electronically to the roadside system when a vehicle passes a charging point. The code may identify the vehicle, the driver, or the driver’s account. The complexity of the charging scheme is determined by the structure of the roadside system. Read-only tags are a proven and reliable technology. Special tags could easily be provided for occasional visitors. Their main disadvantage is that only one vehicle can be processed at a time so that lane specific roadside units are required for multilane environments. A second disadvantage is that read-only tags provide little opportunity for integration with rapidly developing driver information systems (May 1993b, 25).

3: **Read and Write Tags**

Read and write tags allow for information to flow from the roadside to the vehicle as well as in the other direction. The tag could be read at special facilities and would provide the user with an independent list of recent transactions. The tag’s two-way communications device increases the feasibility of multilane operation and may permit duration-based charging systems.\(^2\) The main disadvantage of such tags is that their complexity makes it difficult to equip occasional visitors. Furthermore, the low level of communication between the tag and the roadside limits the opportunities for integration with driver information systems (May 1993b, 25-26).

\(^2\)Duration-based charging systems charge motorists based on the amount of time spent in the restricted area (see Appendix 2).
4: Automatic Debiting Transponders

Automatic debiting transponders are similar to read-write tags, but operate at higher transmission speeds and provide more reliable two-way communication with the roadside. This increases the feasibility of multilane operation and duration-based charges. The high quality of two-way communication should allow for integration with driver information systems. However, current systems require a link to the vehicle’s battery which makes them vulnerable to tampering. A second disadvantage is that due to their complexity, it would be expensive to install automatic debiting transponders on occasional vehicles (May 1993b, 26).

5: In-vehicle Metres

In-vehicle metres provide a link between the transponder and sensors in the vehicle, such as the odometer. This would permit charges to vary directly with congestion levels by varying the charging rate based on the time taken to travel a specified distance. In-vehicle metres are currently in the development stage and are not yet a proven technology. Because they require links to the vehicle’s sensors, they are vulnerable to tampering and expensive to install on occasional vehicles (May 1993b, 27).

C: Payment and Accounting Systems

There are two types of payment systems associated with road pricing: prepayment and postpayment. Prepayment systems require motorists to pay in advance for use of the road system. This can be accomplished in one of three ways: (1) motorists may maintain an account from which
charges are deducted; (2) motorists may purchase credits which are stored on a smart card\(^3\); and (3) motorists may purchase a subscription which allows for unlimited use of the roads within a specified time and area (similar to a transit pass).\(^4\) Under a postpayment system, the motorist is billed periodically for charges incurred (May 1993b, 27-28). Generally, prepayment systems better preserve the privacy of the motorist while postpayment systems offer greater opportunities for auditing charges.

**D: ROADSIDE COMMUNICATION TECHNOLOGIES**

1: **Manual Inspection**

Manual inspection can be used in a limited lane, low speed environment in tandem with a sticker based system. While manual inspection severely limits the complexity of the charging system, it is easy to implement, operate, and understand.

2: **Low Frequency Radio Frequencies (RF)**

Low frequency RF are transmitted from loops in the roadway to an electronic tag mounted underneath the vehicle. A major disadvantage of low frequency RF is that the electronic tag must be mounted underneath the vehicle because of the short range of the radio signal (Thompson 1990, 528).

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\(^3\)A smart card is similar to a photocopy card and is normally inserted into a smart card reader located on-board the vehicle. The smart card can store value or credits which would be debited according to instructions received from the roadside transmitter. The smart card could be recharged at designated machines located at gasoline stations or other facilities (Hau 1992a, 29-31).

\(^4\)A major disadvantage of such a system is that it does not confront the motorist with the marginal cost of travel.
3: **High Frequency RF**

High frequency RF, or microwaves, are a proven technology for single lane sites (May 1993b, 31). They can be transmitted from overhead gantries and offer sufficient transmission rates for use with smart card systems (Thompson 1990, 528). High frequency RF is used in most electronic toll collection systems today (Thompson 1990, 528).

4: **Infra-red Systems**

Infra-red systems are well developed for route guidance technology, but they have received little attention for use in electronic road pricing (Thompson 1990, 528). While the technology is mature, its application to road pricing is still in the development stage (May 1993b, 31).

E: **Vehicle Detection**

Vehicle detection is the most challenging technical component of electronic road pricing. The detection system must be able to identify and classify all vehicles at enforcement sites. Because lane changing and straddling make vehicle detection and classification particularly difficult, it has been suggested that vehicles not be allowed to change lanes when passing an enforcement site (May 1993b, 32). Four prominent vehicle detection and classification technologies are: (1) inductive loop and axle sensor systems; (2) pulse-mode microwave systems; (3) infra-red light beams; and (4) video image processing (May 1993b, 32). Although none of these technologies currently meet the stringent enforcement requirements of electronic road pricing, “microwave, infra-red, and video imaging all appear to offer potential for further development” (May 1993b, 33).
F: UNIQUE VEHICLE IDENTIFICATION TECHNOLOGIES

1: Photo-logging

Photo-logging uses a high speed camera to photograph the rear licence plate of noncompliant vehicles. A problem with photo-logging is that the quality of the picture is impaired by poor climatic conditions. Despite this drawback, photo-logging is widely used to automatically record the licence plates of speeding vehicles (May 1993b, 34).

2: Video-logging

Video-logging operates in much the same way as photo-logging, but uses a video camera to film the front licence plate of the vehicle. An advantage of video-logging is that all vehicles can be filmed, so that details about each vehicle can be stored until the validity of the transaction can be verified (May 1993b, 34).

Both photo and video-logging are unable to record all licence plates because a vehicle’s plates may be blocked from the camera’s view by adjacent vehicles. The system’s accuracy is further undermined by drivers who attempt to evade detection (May 1993b, 34). Nonetheless, the fact that photo-logging is currently used to record the licence plates of speeding vehicles is a testimony to the potential of this technology for use in electronic road pricing.
APPENDIX 2

ROAD PRICING CHARGING STRUCTURES

A: INTRODUCTION

There are three main charging structures which have been proposed or envisaged by transport professionals for practical implementation in a road pricing scheme: (1) point or cordon charges; (2) distance-based charges; and (3) duration-based charges1 (May 1993b, 18). The choice of charging structure has important implications for motorist response, political acceptability, and the system’s technical requirements. The alternate charging structures are described below.

B: POINT OR CORDON CHARGES

Point or cordon structures charge a fee to pass a particular point or cordon line. The complexity of the charging system is largely determined by the technology employed. Charges can vary by time of day, vehicle type, and direction of travel (May 1993a, 15). Vehicles can be charged to cross one or a series of cordon lines (May 1993a, 15). The system is relatively simple to operate and easy for the public to understand. However, congestion and parking pressures may build up adjacent to the cordon line(s). The system may be perceived as unfair to residents who live close to the cordon but must cross it to get to work. Critics argue that a cordon system is too inflexible and fails to adequately approximate the marginal costs of driving.

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1May (1993b) uses the term time-based charges instead of duration-based charges. The term duration-based is retained in this thesis to avoid confusion with other types of charging structures which are also time-based in the sense that the charge will normally vary by time of day.
C: **DISTANCE-BASED CHARGES**

Distance-based systems levy a charge based on the distance travelled within a defined area. Charges can vary by time of day and vehicle type. While distance-based charges provide a reasonable approximation of the costs associated with a particular journey, they do not relate dynamically to congestion levels (May 1993a, 16). They are easy to understand, but would require relatively complex technology to implement.

D: **DURATION-BASED CHARGES**

Duration-based systems charge motorists for the amount of time spent in a predefined area. In addition to varying the charge by time of day and vehicle type, charges could vary based on vehicle activity (driving, idling, parking) (May 1993b, 18). A variant of this system is to charge motorists based on the amount of time taken to travel a predefined distance. Such congestion-based systems directly relate the charge to congestion levels. A major drawback of all duration-based systems is that the charge is not known to motorists in advance (May 1993b, 16). The effect of such a system on driver behaviour is unknown. A second drawback is that duration-based systems encourage motorists to drive more aggressively in order to reduce the charge incurred (May 1993a, 16).
APPENDIX 3
ROAD PRICING EXPERIENCES IN OTHER COUNTRIES

A: SINGAPORE (Original 1975-1989, Revised 1989-present)

1: Purpose

The original Area Licensing Scheme (ALS) was “aimed at discouraging the widespread use of cars for commuting purposes” (Menon, Lam, and Fan 1993, 44). The objective of the system was revised in 1989 to “use the ALS as a traffic management tool to curtail congestion” (Menon, Lam, and Fan 1993, 44).

2: Description

The ALS is a cordon pricing system. Motorists must purchase a daily or monthly licence in order to enter the Restricted Zone (RZ), a five square kilometre area encompassing Singapore’s central business district. Under the original scheme, the ALS operated during the morning peak-period (7:30-10:15 a.m.) and the fee per day was S$5 (US$3.13) for private cars, S$10 (US$6.25) for company cars, and S$2 (US$1.25) for taxis. All other vehicles, including cars with more than three occupants, were exempt from the fee (May 1993a, 15; Menon, Lam, and Fan 1993, 44). Following the 1989 reforms, restrictions on access were extended to the evening peak-period (4:30-6:30 p.m.). At the same time, the fee for cars, taxis, goods vehicles, and unscheduled buses was set uniformly at S$3 (US$1.88). The fee for company cars was lowered to S$6 (US$3.75) and

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1 The fee for private cars was raised from S$3 to S$5 in 1980 (Morrison 1986, 94).

2 The 40 percent drop in the fee charged to private vehicles emphasizes that the primary objective of the ALS is traffic management not revenue generation.
motorcycles were charged a S$1 (US$0.63) fee (Menon, Lam, and Fan 1993, 45). This change in the fee structure reflects the more precise objective of curtailing congestion adopted as part of the 1989 ALS reforms.

3: Technology Employed

The ALS is a completely manual system. Vehicles must display a daily or monthly sticker in order to enter the RZ during the restricted hours. Traffic wardens, stationed at each of the 26 access points to the RZ, inspect the validity of stickers as vehicles cross the cordon line (Hau 1992a, 77). The high visibility of the stickers allows traffic wardens to verify their validity without vehicles having to stop (Hau 1992a, 77).

The Government of Singapore has decided to replace its labour intensive ALS with an electronic road pricing (ERP) system. The initial objective is to replace manual sticker inspection with a system of electronic verification; eventually, a sophisticated ERP system will be installed which will allow for a flexible pricing structure (Hau 1992a, 57). The proposed system would utilize smart card technology and a series of charging points located throughout the country. The system would be enforced by photographing the rear licence plate of all noncompliant vehicles (Menon, Lam, and Fan 1993, 48). Three proposed systems are to be evaluated as part of a demonstration project scheduled to be carried out in 1994 (Menon, Lam, and Fan 1993, 48).

4: Evaluation

The ALS is generally considered very successful. Following implementation in 1975, total inbound traffic into the RZ during the restricted hours fell by 44 percent (Menon, Lam, and Fan
1993, 44). By 1989, despite a 30 percent growth in employment in the RZ and a 77 percent increase in the number of vehicle registered in the country, inbound traffic during the restricted hours remained below 70 percent of the pre-ALS level (Menon, Lam, and Fan 1993, 45).

The 1989 reforms caused a reduction in the volume of previously unrestricted motorcycles and goods vehicles and a slight increase in car and taxi traffic (Menon, Lam, and Fan 1993, 45). The introduction of the evening restricted hours caused a 44.5 percent reduction in inbound traffic and a 30 percent reduction in outbound traffic during the evening peak. Since traffic was only restricted in the inbound direction, the reduction in outbound traffic indicates that through traffic was substantially reduced (Menon, Lam, and Fan 1993, 45).

The ALS also had a significant effect on mode share. Prior to the introduction of the ALS in 1975, car drivers represented 47 percent of inbound commuters during the morning peak. By 1983, this had fallen to 15 percent while transit’s share of work trips to the RZ rose from 33 to 69 percent (Menon, Lam, and Fan 1993, 46; Pendakur 1987, 212). The modal split ratio remains about the same today (Menon, Lam, and Fan 1993, 46).

B: HONG KONG (1983-1985)

I: Purpose

The primary objective of Hong Kong’s electronic road pricing (ERP) experiment was to test “the technical, economic, and administrative viability” of an electronic system (Hau 1990, 203). ERP was seen as a way to combat increasing congestion in Hong Kong; through the 1970s, the number
of registered vehicles in Hong Kong doubled while road length increased by only 17 percent (Hau 1990, 204).

2: Description

Field trials, involving 2500 vehicles fitted with electronic number plates (ENPs), were conducted between 1983 and 1985. Each time a vehicle passed a toll site, a charge was registered against the owner’s account. The system generated monthly bills giving a breakdown of toll sites crossed (Hau 1990, 205).

3: Technology Employed

The Hong Kong ERP experiment was entirely electronic. The system used a read-only tag (the ENP) which transmitted an identification number to a receiver loop whenever a vehicle passed a toll site (Dawson and Catling 1986, 130). Inductive loops were used for vehicle to roadside communication (May 1993b, 30). Enforcement was accomplished by roadside television cameras, which automatically took pictures of vehicles with faulty or missing ENPs (Hau 1990, 205).

4: Evaluation

The ERP system was a technical success (Hau 1992a, 44). The system accurately billed over 99 percent of toll site crossings and vehicles had less than a 1 in 10 million probability of being billed for crossings which they did not make (Dawson and Catling 1986, 132). However, at the end of the pilot project in 1985, the Hong Kong government decided not to implement electronic road pricing.
There are a number of reasons why ERP was not implemented. First, many Hong Kong residents objected to the government being able to track their movements and felt that ERP invaded their privacy. The 1984 signing of the Sino-British declaration, under which Hong Kong was to be handed over to China in 1997, heightened people's sensitivity to the issues of privacy and 'big brother' government (Hau 1990, 210). Second, ERP was introduced at a time when traffic conditions in Hong Kong were actually improving. The growth in real income and the concomitant demand for private vehicles was dampened by a crash in the stock and property markets in 1982 and by a fiscal restraint measure introduced by the government in May of the same year. The opening of the Island Line route of the Mass Transit Railway in 1985 and the Island Eastern Corridor in 1984 served to relieve congestion levels (Hau 1990, 207). Between 1979 and 1984, the average speed of traffic in the urban area actually increased from 20 to 28 kilometres per hour, a remarkable forty percent improvement (Hau 1990, 207). Finally, ERP was not implemented because of public mistrust of the government's promises and assertions. People were sceptical of the government's promise to lower annual licence fees and first registration taxes. Some felt that ERP was unnecessarily expensive and that the use of patented ERP technology was tantamount to exporting employment to the United Kingdom (Hau 1990, 211). It should be emphasized that the government failed to implement ERP in Hong Kong for political not technical reasons.

C: NORWAY - Bergen (1986-present), Oslo (1990-present), Trondheim (1991-present)

1: Purpose

The primary purpose of the Norwegian toll rings is to raise revenue for infrastructure investment (May 1992, 319). The systems are not designed to reduce congestion levels.
2: Description

The Norwegian systems all operate with a cordon around the central area. In Bergen, motorists are charged a fixed price for entry into the city centre between 6 a.m. and 10 p.m. on weekdays. A similar flat fee is charged to enter Oslo’s city centre, with charges operational 24 hours a day. Trondheim charges an entrance fee between 7 a.m. and 5 p.m., with a surcharge during the peak periods (May 1993a, 15).

3: Technology Employed

The toll rings in Oslo and Trondheim offer drivers the choice of either manual or electronic toll collection (May 1993a, 15). The electronic option allows for both prepayment and postpayment of tolls (May 1993a, 15). The Bergen toll ring operates with a manual system of toll booths encompassing the city centre (May 1993a, 15).

4: Evaluation

Compared to the ALS in Singapore, the Norwegian toll rings have had very little effect on traffic levels. In Bergen, the 5 Kroner (US$0.80) fee charged to enter the city centre reduced car traffic by 7 percent while the 10 Kroner (US$1.60) fee in Oslo resulted in a mere 5 percent reduction in traffic (Hau 1992a, 39; May 1992, 324). There are two explanations for these low price elasticities. First, because the overriding objective of the toll rings is to raise revenue, the fee charged is uniform throughout the day. This does nothing to encourage motorists to travel outside of the congested peak-period (May 1992, 324). Furthermore, the toll may not be high enough to

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3Hau (1992a, 38) reports that charges are levied in Trondheim beginning at 6 a.m. and on weekdays only.
Appendix 3: Road Pricing Experiences in other Countries

encourage motorists to switch to an alternate mode of travel. Second, particularly in Oslo, public transit does not provide a viable alternative to the private automobile for many long distance commuters (May 1992, 324).

D: RANDSTAD REGION - THE NETHERLANDS

1: Purpose

The feasibility of introducing road pricing in the Randstad region is currently being studied by a special task force of the Dutch Ministry of Transport. "The objectives of road pricing are to: (a) reduce the growth of car use generally, as measured by total vehicle kilometres travelled, by 14 percentage points (from 72% to 58%), and that of car use during the peak by 30 percentage points (from 72% to 42%), (b) reduce waiting time costs by 19%, so that the area would be almost congestion-free by 1996, and (c) use part of the revenues for the financing of roads" (Hau 1992a, 52). The Dutch road pricing proposals emphasize environmental improvements as well congestion relief and revenue generation (May 1993a, 15).

2: Description

The Randstad is a highly urbanized area encompassing the four major cities of Amsterdam, Rotterdam, the Hague, and Utrecht. Traffic conditions in the region are expected to deteriorate because of population pressures and an increase in automobile usage (Hau 1992a, 51). It was against the backdrop of increasing congestion that, in 1988, the Dutch Government commissioned a "special task force for Rekening Rijden -- which literally means travel accounting or road pricing" (Hau 1992a, 51). Despite the government's 1988 policy decision to implement road pricing in the Randstad, implementation has been delayed by public scepticism that road pricing
represents simply another revenue raising device on the part of the government (Hau 1992a, 54). Technical considerations were also a factor in the government's decision to delay implementation. While the government initially decided to limit the first phase of road pricing to "electronic toll collection at the tunnels under the Project Ring Toll," the Minister of Transport recently announced that a system of supplementary licences for use of the main road network during peak hours would be implemented instead (Hau 1992a, 54).

3: Technology Employed

The Dutch proposal relies upon the use of a smart card which would be debited each time the vehicle passed a charging point. Because this is a prepayment system, privacy is fully protected except in the case where the value on the card drops below a minimum threshold. In such a case, or when an irregularity is detected during the charging process, a photograph would be taken of the vehicle involved and a notice sent to its owner (Stoelhorst and Zandbergen 1990, 68, 70).

4: Evaluation

The Randstad road pricing proposals are an ambitious attempt to implement road pricing over a large geographic area. Although some technical issues are yet to be resolved, political opposition represents the biggest obstacle to implementation. While desk studies have shown road pricing to be the preferred transport option in the Randstad, the public remains sceptical of a scheme under which they would be forced to pay for road space which was formerly provided free of

See Hau (1992a, 53-54) for a discussion of the benefits of road pricing in the Randstad.
charge. The Dutch experience emphasizes the importance of incorporating provisions for public acceptability when formulating a road pricing strategy.

E: OTHER NOTABLE ROAD PRICING EXPERIENCES

I: London, England

Road pricing has been examined on a number of occasions as a possible solution to London’s congestion problems. Much of the work in Britain regarding road pricing is being carried out with an eye towards eventual implementation in London. Research into the application of road pricing in Britain dates back to a 1964 study of road pricing commissioned by the U.K. Ministry of Transport (U.K. Ministry of Transport 1964). *Road Pricing: The Economic and Technical Possibilities*, commonly referred to as the Smeed report in reference to its panel chairman, sets out nine operational criteria for an effective road pricing system. These criteria are still widely cited in the literature today:

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

(U.K. Ministry of Transport 1964, 7)

A three year study of congestion charging for London is currently being conducted by the Ministry of Transport (Hau 1992a, 56; May 1993a, 16).
2: Cambridge, England

Cambridge, England is currently developing a road pricing scheme based on smart card technology (Hau 1992a, 55). Unlike the cordon schemes in Singapore and Norway, the Cambridge proposal is based on continuous rather than point pricing. Under the proposed system, the charge to motorists would vary dynamically with congestion levels. During peak periods, the smart card would be debited whenever travel time exceeded a specified threshold for each 0.5 kilometres travelled (Hau 1992a, 55-56; May 1992, 322). Motorists’ behaviour under such a system is difficult to predict because the charge would not be known in advance. The Cambridge proposal calls for road pricing revenues to be allocated for public transit improvements (Hau 1992a, 56).

3: United States

There are no U.S. examples of areawide road pricing schemes (Arrillaga 1993, 41). In 1973, the Urban Mass Transportation Administration (UMTA) initiated a demonstration program which it hoped would lead to road pricing being implemented in the United States. The UMTA’s initiatives were unsuccessful and in 1978, the demonstration program was abandoned (Arrillaga 1993, 39; Higgins 1986, 145-46). Today, increasing congestion, issues of air pollution, and technical advances in road pricing technology are some of the reasons for renewed U.S. interest in road charges. The federal government’s Intermodal Surface Transportation Efficiency Act (ISTEA) has established a pilot program for testing congestion pricing in the United States (Arrillaga 1993, 40). Most of the U.S. interest in road pricing comes from California, a testimony the fallacy of supply-side solutions to the problem of traffic congestion.
a. **San Francisco, California**

The Bay Area proposal for implementing peak-hour congestion charges on the San Francisco-Oakland Bay Bridge has been selected for possible federal funding under ISTEA’s congestion pricing pilot program (Arrillaga 1993, 41). The proposal calls for low occupancy vehicles to pay an increased toll during peak periods on the Bay Bridge. Improvements are also planned for parallel transit services and ride sharing programs (Arrillaga 1993, 41).

b. **Orange County, California**

The ten mile, four lane freeway to be built in the median of Orange County’s Riverside Freeway is California’s most prominent road pricing project (Arrillaga 1993, 41; Elliott 1992, 526). Tolls on this private freeway will be collected electronically using a transponder affixed to the vehicle’s rearview mirror. Charges will vary based on the time of day and prevailing congestion levels. Car pools of three or more occupants will be eligible for reduced or discounted access. The existing lanes of the Riverside Freeway will continue to be free to all motorists (Arrillaga 1993, 41-42).

c. **San Diego, California**

The San Diego Association of Governments has received a grant from the Federal Transit Administration to implement road pricing in the I-15 corridor (Arrillaga 1993, 42). Under the proposal, excess capacity in the high occupancy vehicle (HOV) lanes would be rented to single occupancy vehicles (SOVs). Phase one of the project would involve a low technology permit system to authorize access to the HOV lanes (Arrillaga 1993, 42). The project’s second phase would automate access and toll collection. The project is awaiting approval from the state legislature and the Federal Highway Administration (Arrillaga 1993, 42).