Congestion Pricing:
Policy Dimensions, Public Rejection and Impacts
by
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Abstract

This thesis makes three related contributions to the broad literature on congestion pricing. First, it examines three policy dimensions that underlie pricing: the economic arguments that motivate it, the technological options that enable it, and the equity concerns raised by its implementation. The thesis unites these dimensions and shows that not only can they be in tension with each other, but they also collectively affect pricing’s public acceptance. Second, a new framework is proposed that roots the public rejection of congestion pricing along the dimensions of inequity and uncertainty, influenced by societal views and institutional issues. Using this framework, a number of political problems including collective action, credible commitment, free riding and loss aversion are posed as specific combinations of perceived inequity and uncertainty about congestion pricing’s benefits and costs. Societal views are then shown to moderate the public’s sentiment about this policy. Afterwards, this framework is linked to institutional issues, particularly the political process that could constrain and block the approval of a congestion pricing program. Finally, the thesis evaluates the effectiveness of pricing as a policy tool. The impacts of congestion pricing—both positive and negative—are first considered. Afterwards, the thesis compares pricing to a small subset of other congestion mitigation options, including taxing vehicle miles traveled, regulating automobile ownership, and regulating and taxing parking supply. The revenue generating potential of these tools is also reviewed. Throughout the thesis, evidence is drawn from both successful (e.g., London, Stockholm and Singapore) and failed (e.g., New York City, Edinburgh, Manchester and Hong Kong) attempts to introduce congestion pricing. The research concludes by delineating a number of important considerations when exploring pricing as an option to mitigate traffic congestion.
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Chapter 1

Introduction

1.1 Motivation

The Texas Transportation Institute estimates that road traffic congestion in 2011 caused Americans living in metropolitan areas to travel an additional $5.5$ billion hours and to purchase an extra $2.9$ billion gallons of fuel (Schrank et al., 2012). These economic losses totaled to $121$ billion and do not even include the costs associated with greenhouse gas emissions, air pollutants, traffic accidents, infrastructure damages, visual and noise intrusion, and energy insecurity (Anas and Lindsey, 2011). Delays due to congestion required travelers having to allow for $60$ minutes to make a $20$-minute trip under light traffic (Schrank et al., 2012), which negatively impacts their quality of life (Schneider, 2013).

Economists view congestion as an external cost imposed by each road user on every other traveler by adding to the delay they encounter. This externality is usually excluded from the comparison of private marginal benefits and costs when motorists choose to drive. Such is a classic example of the *Tragedy of the Commons* (Hardin, 1968), a free rider problem associated with public goods, and which illustrates the harmful effects of unabated negative externalities. In order for users to internalize the externalities they impose on society, Pigou (1920) proposed a tax or levy to ensure that motorists' private costs were consistent with the true costs of driving. Since Pigou's seminal work, there have been many significant contributors to the congestion pricing literature, notably Vickrey who "wrote some 40 articles that treated most road-pricing issues" (Lindsey, 2006).

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Today, congestion pricing (CP) is considered by many to be an efficient market-based response to mitigate excessive traffic. For example, Mayor Livingstone (2004) recounts the severe congestion Central London was experiencing prior to charging. By the year 2000, average speeds dropped below 10 miles per hour, which was "back to the speed of the Victorian horse and cart." Around 50% of vehicle travel time to Central London was spent waiting in traffic (Bhatt et al., 2008), and the economic costs for businesses was estimated to be over £100 million per year (Livingstone, 2004). Hence, in 2003, the City of London introduced a £5 fee for drivers who enter or are within the designated charging zone (Bhatt et al., 2008). This led to over a 30% decrease in traffic congestion (Anas and Lindsey, 2011), as well as shifts to alternative modes, notably walking, biking and public transit (TFL, 2004). To help characterize the magnitude of congestion pricing's impacts, Table 1.1 summarizes some of the estimated benefits and costs of the London and Stockholm CP programs.

However, while this solution has enjoyed operational success in a number of major cities (e.g., London, Stockholm and Singapore), there have also been high profile rejections of planned CP programs (e.g., New York City, Edinburgh, Manchester and Hong Kong) (CS, 2009). Understanding these failures requires studying the factors that affect the public acceptance of congestion pricing. This first necessitates exploring the policy dimensions that underlie CP, and then identifying some common sources of public rejection. Furthermore, the impacts of CP—both positive and negative—need to be well understood, and then weighed when deciding to pursue this policy. Implementing CP requires generating substantial political support among both road and non-road users. Hence, a clear rationale must be established from the start that the severity of the congestion problem indeed warrants a radical policy like pricing to be considered.

1.2 Scope

This thesis examines the economic, technological and equity dimensions of congestion pricing, and studies how these three affect its public acceptance. I also consider the sources of public rejection of CP, which include the perceived inequity and uncertainty about the program's costs and benefits, negative societal views on pricing, as well as constraints imposed by the
Table 1.1: Benefits, costs and impacts of London and Stockholm congestion pricing programs. 

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Gross benefits (USD)</td>
<td>$360 M</td>
<td>$130 M</td>
</tr>
<tr>
<td>Total costs (USD)</td>
<td>$255 M</td>
<td>$40 M</td>
</tr>
<tr>
<td>Net benefits (USD)</td>
<td>$105 M</td>
<td>$90 M</td>
</tr>
<tr>
<td>Congestion delays</td>
<td>-30%</td>
<td>-33% to -50%</td>
</tr>
<tr>
<td>Traffic volumes</td>
<td>-12% all vehicles</td>
<td>-16% within cordon</td>
</tr>
<tr>
<td>$NO_x$</td>
<td>-12%</td>
<td>-8.5%</td>
</tr>
<tr>
<td>$PM_{10}$</td>
<td>-12%</td>
<td>-13%</td>
</tr>
<tr>
<td>$CO_2$</td>
<td>-19%</td>
<td>-14%</td>
</tr>
</tbody>
</table>

political process. In addition, I probe some of the adverse impacts of congestion pricing, and compare CP to alternative policies that mitigate traffic congestion. The revenue potential of CP and these other traffic mitigation options are also explored.

Throughout this thesis, I use congestion pricing synonymously with road pricing, which often has a broader definition. The operational definition of CP adopted here is charging for access or use of a road network for the purpose of reducing congestion. It is important to keep in mind that this definition is distinct from tolling, which is not the focus of this study. The former attempts to manage travel demand and mitigate congestion, while the latter’s primary purpose is to finance the construction and maintenance of roads, bridges and tunnels (Li and Hensher, 2012). In addition, the examples I use throughout this thesis are primarily drawn from cordon-based programs. Cordon charging is when charges are placed on motorists to drive within or into a congested area within an urban center (FHWA, 2008c). This is different from priced lanes, which are fees for low occupancy vehicles to use high-occupancy vehicle lanes. Again, priced lanes are not the focus of this thesis.

1.3 Contributions and Organization

This thesis synthesizes ideas from a broad literature on congestion pricing, and makes a number of related contributions. These contributions are organized around the three core chapters of this thesis, which are briefly discussed below.
1.3.1 Chapter 2

In Chapter 2, I examine three important policy dimensions of congestion pricing: the economic arguments that motivate it, the technological options that enable it, and the equity concerns raised by its implementation. I show that not only can these three dimensions be in tension with each other, but they also collectively influence the public acceptance of CP. The chapter first takes a markets perspective on traffic congestion externalities, and then depicts how the current system of road space allocation is prone to a commons problem. I then present the rationale for using pricing as a means to mitigate automobile externalities. The mechanics of the program are introduced, along with the enabling technologies. Then, the issue of equity, which is central to the public acceptance of congestion pricing, is discussed.

The chapter then introduces a new framework that links economics, technology and equity, and illustrates how they collectively affect public acceptance. I focus on the trade-offs across these three dimensions. For instance, economic efficiency versus equity is a central consideration for any CP program (Levinson, 2010). Redistributing the collected revenues serves as an important tool to manage any resulting inequity issues, in which the availability of transportation alternatives become key (Jones, 2003). However, the chosen CP technology imposes some limits on the efficiency of the charge collection, which may erode away the revenues collected (Lindsey, 2006). The chosen technology can also have equity implications, such as when users need to purchase electronic equipment to participate in the CP program (FHWA, 2008b).

I also show how these three dimensions together influence the public acceptance of CP. While CP is an idea motivated by economics, its success is moderated by the public perception of the congestion problem. That is, the public needs to perceive a severe enough level of congestion to believe that pricing is warranted (Ison and Rye, 2005). The transparency of a CP program is also an important factor that affects public acceptance (Allen et al., 2006), which effectively limits the complexity of the chosen pricing scheme and technologies that operationalize it. Finally, from a public acceptance perspective, equity is perhaps the most important dimension. In fact, equity concerns are often a major source of public rejection of CP, as discussed in the next chapter.
1.3.2 Chapter 3

In Chapter 3, I propose a new framework that roots the public rejection of congestion pricing along the dimensions of inequity and uncertainty, influenced by both societal views and institutional issues. I build on previous approaches by framing the political problems of collective action (Albalate and Bel, 2009, Schaller, 2010), credible commitment (Manville and King, 2012), and free riding and loss aversion (King et al., 2007) as combinations of inequity and uncertainty about the CP program's costs and benefits. I then show that societal views also play an important role by moderating the public's sentiment on pricing (e.g., through how the media portrays CP). I then link the framework to institutional issues, particularly the political process that could constrain and block the approval of a CP proposal.

In developing this framework, I primarily draw from the experiences in New York City, Edinburgh, Manchester and Hong Kong, which all failed to get CP implemented. In New York City for example, collective action from a small interest group outside the proposed charging zone played a significant role in blocking the introduction of this policy (Schaller, 2010). In the case of Edinburgh, CP became a highly contested topic between the incumbent government and its opposition, which then had a major impact on the ensuing referendum's negative vote of the proposal (Albalate and Bel, 2009). The complexity of a two cordon scheme (Hensher and Li, 2013) and poor media representation (Vigar et al., 2011) did not help win support for congestion pricing in Manchester. In Hong Kong, distrust in the government (Manville and King, 2012) and organizational issues (Ison and Rye, 2005) were some of the problems.

I end the chapter by presenting the following best practices to improve the public acceptance of CP, which include: a strong public education, outreach and media campaign; hypothecating revenues and upfront investments in transit; demonstration projects; strong leadership and clear authority; and the use of exemptions, subsidies and effective scheme design. These solutions collectively address the four sources of public rejection I identify in this chapter. For instance, making upfront transit investments not only reduces any uncertainties the public has on the benefits of CP (Manville and King, 2012), but it also addresses some inequity issues by ensuring motorists have adequate alternatives after CP's introd-
tion (Levinson, 2010). A strong media campaign can also help highlight the benefits of the CP program instead of solely focusing on its costs (Vigar et al., 2011).

1.3.3 Chapter 4

The previous two chapters have implicitly assumed that congestion pricing is the solution to road traffic congestion, and that the main challenges associated with CP are primarily related to its public acceptance. However, CP is only one policy tool among a portfolio of solutions geared towards mitigating traffic congestion. Furthermore, CP, like other transportation policies, has both positive and negative impacts. Chapter 4 explores these issues. First, I briefly review some of the positive impacts of road pricing. In London and Stockholm for example, these benefits include reductions in traffic congestion, emissions and road accidents (Evans, 2007, Eliasson, 2009).

Afterwards, I consider some of the adverse consequences of congestion pricing. For instance, the Singapore congestion charges might have initially been set too high, which led to inefficient traffic allocation (Phang and Toh, 2004). It is also possible that CP revenues could be misused. Instead of hypothecating CP revenues to transit which could offset some of the increased costs on Stockholm commuters and businesses, the permanent introduction of CP in Stockholm earmarked revenues to a new ring-road as this was believed to improve acceptability among motorists (Börjesson et al., 2012). This compromise has negative environmental implications, such as inducing further sprawl. The congestion charges could also affect other goods and services across the transportation system. For example, a study by Arup (2004) finds that parking revenues in Central London have gone down since the introduction of CP. If parking operators had reduced prices to compensate for the revenue decrease, then pricing's congestion reduction effectiveness could have been undermined. In addition, there is also evidence that retailers experienced worse sales after CP was introduced, prompting some of them to consider relocating out of the cordon zone (Winsor-Cundell, 2003).

I then examine three other policies that mitigate traffic congestion as alternatives to CP: taxing vehicle miles traveled, regulating automobile ownership, as well as regulating and taxing parking supply. I compare them to congestion pricing, with the goal of better locating where CP sits among these options. I also review the revenue potential of these
policies (TRB, 2006, Balducci et al., 2011), which is a separate (and important) dimension to its traffic reduction capabilities. The chapter shows that there are again trade-offs between these two dimensions (e.g., the optimal charge to maximize revenues may not be equivalent to the optimal charge to minimize congestion) (Mahendra et al., 2012). Furthermore, previous issues, such as economic efficiency versus equity, again arise. For instance, in regulating automobile ownership, a bid price system (e.g., Shanghai) is more efficient and generates revenues, while a lottery (e.g., Beijing) may be viewed as fairer (Chen and Zhao, 2013a).

The chapter ends by presenting a small case study of how the Greater Toronto-Hamilton Area (GTHA) selected the funding tools for their $50 billion transportation plan to mitigate traffic congestion (Metrolinx, 2008). The case study aims to illustrate: how different policy options can be combined as a part of a portfolio of solutions; examples of some of the best practices in getting a transportation plan implemented; and the trade-offs in selecting policies, particularly between shifting costs among stakeholders and obtaining their support.

1.3.4 Chapter 5

Finally, Chapter 5 summarizes the key findings of this thesis. This chapter reviews some of the main topics discussed and how they are related to each other. In addition, this chapter also provides important considerations when deciding on whether to pursue congestion pricing as a policy option. Areas of future research are also discussed. I give particular focus on some of the associated benefits of simply discussing road pricing with the public, such as increasing both the public's education on and acceptance of transportation policies in general.
Chapter 2

Public Acceptance of Congestion Pricing: Economic, Technological and Equity Dimensions

2.1 Chapter Overview

This chapter unites the economic principles, existing technologies and equity considerations that underpin congestion pricing, and illustrates how they collectively affect CP’s public acceptance. First, I present the rationale for CP, taking primarily an economics perspective. In particular, the chapter depicts how the current system of road space allocation is prone to a commons problem. Afterwards, I discuss the technologies that enable congestion pricing, and then elaborate on important equity considerations. I propose a new framework that synthesizes the ideas discussed in this chapter by showing that the underlying economics, technological choice and equity considerations are linked to each other in that they not only can be in tension with each other, but they also collectively affect the public acceptance of congestion pricing.

2.2 Traffic Congestion and Economics

2.2.1 An Externalities Problem

When a driver decides to use public roads, he or she typically considers the private costs (e.g., travel time, fuel, etc.) associated with this choice. However, this analysis excludes the social costs the motorist imposes on all other road users (e.g., traffic congestion, air pollution, etc.).
This externalization can give rise to two problems (Nash, 2008). First, this scarce roadway resource will be inefficiently allocated. That is, roads may not be apportioned to those users who value them most since drivers cannot pay to get ahead of traffic. As such, the "rule of first capture" is likely to prevail, where effort and time become the primary means to which roads are distributed.

Second, road usage will also not be efficient as people will tend to overuse them. This is a classic case of the Tragedy of the Commons (Hardin, 1968), where the ability to externalize costs gives rise to the overconsumption of a resource. While society may be better off if everyone did not overuse public roads (e.g., less traffic for all drivers), motorists will always have an incentive to overconsume as long as they do not have to internalize the full costs of driving. In fact, mathematical models of traffic flow predict that the solution which minimizes the travel time of each individual driver is never better than the corresponding solution that aims to reduce the travel time for the public as a whole (Sheffi, 1985).

### 2.2.2 Supply Side Solutions to Traffic Congestion

Traffic congestion has been addressed through multiple approaches. Early attempts provided more supply by building extra road capacity, which has become a more limited option today given that most congested areas face land availability constraints. Furthermore, adding new roads may not always improve traffic. For instance, when all motorists act selfishly and switch to new routes that they perceive to be best for them, traffic can actually worsen. This is known as the Braess Paradox, which is based on recorded traffic degradation after a road expansion project in Stuttgart, Germany (Braess et al., 2005).

Other paradoxes, namely the Pigou-Knight-Downs and Downs-Thompson, exist in the literature. Both predict poorer transportation system performance after the provision of new roads since the new supply attracts more road users away from competing modes such as public transit (Arnott and Small, 1994). When transit users shift to the automobile due to new road supply, the effective cost of public transit can increase due to lower frequencies and poorer service. Building on the work of Mogridge (1997), Basso and Jara-Díaz (2012) show that investing in road infrastructure can increase the generalized costs for transit users, noting the importance of the modal split arising due to the relative prices between driving
and public transport. A common reason that underlies these paradoxes is the divergence between the private and social costs of trips (Arnott and Small, 1994).

Improving alternative transportation modes (e.g., mass transit), using advanced traffic control systems and other supply side solutions could make driving cheaper and more pleasant. However, this might again induce further traffic in the short-run (Anas and Lindsey, 2011). The degradation of transportation system performance due to induced traffic is well documented (Goodwin, 1996). In the long-run, there is also the possibility of induced demand, which stems from land use patterns adjusting to the new levels of accessibility due to improved supply (Cervero, 2002).

Figure 2-1 illustrates the relationship between these two concepts. Initially, let demand and supply be represented by $D_0$ and $S_0$ respectively, where an equilibrium price of $c_0$ is reached at traffic flow $q_0$. Here, the price is a generalization of private costs a driver faces, which could include operating costs, travel times, etc. When supply is raised to $S_1$, the equilibrium shifts to $c_1$ and $q_1$ in the short-run as a result of travelers adjusting their behavior in response to the supply (e.g., some drivers might shift commute times closer to peak hours due to the increased supply). This movement along the short-run demand curve $D_0$ due to the new supply corresponds to induced traffic. In the long-run, the short-run demand curve $D_0$ shifts out to $D_1$ as people make changes in their long-term decisions (e.g., housing relocation) in response to the changes in the transportation system. The shift from $D_0$ to $D_1$ moves along the long-run demand curve $D_{LR}$ and ends in a new long-run equilibrium $(q_{1,LR}, c_{1,LR})$ where both flow and price have increased relative to their previous short-run values. Regardless if the changes are in the short-run or long-run, the benefits from providing new supply are eroded away as more travel is induced due to improved conditions. See Appendix B of FHWA (2005) for more details on induced traffic and induced demand.

Duranton and Turner (2011) provide strong evidence that vehicle-miles traveled increase with roadway lane kilometers for U.S. interstate highways and other types of roads. To properly establish causation (i.e., does building roads induce more traffic or is it the other way around), they employed the routes of major historical expeditions, major rail routes and the proposed routes of interstate highways as instrumental variables in their regressions. Their "Fundamental Law of Road Congestion" concludes that the increased provision of
roads would unlikely relieve traffic congestion, and suggests pricing as the main tool to manage congestion.

2.2.3 Demand Side Solutions to Traffic Congestion

Due to the limitations of supply side solutions, policies that manage travel demand have become increasingly more popular. Most of these policies fall under two categories: command-and-control and market-based approaches (Giuliano and Wachs, 1992). The command-and-control or regulatory approach—such as restricting access to certain urban areas, parking controls, employer-based trip reduction programs, and "odd and even" license plate authorization systems—mandates changes in driving behavior. These policies typically treat drivers uniformly and do not discriminate by willingness to pay (Ruta, 2002). For instance, access restrictions schemes generally limit driving for all motorists, including those who might have been willing to pay a price higher than the additional marginal social cost their trip would have imposed.

In effect, regulatory approaches fail to meet the first problem identified by Nash (2008) of inefficient resource allocation. Broadly speaking, command-and-control policies unnecessarily deprive motorists of the flexibility in complying with government targets (Nash, 2008). This means that drivers would have to comply in a particular manner even if less oner-
ous or costly alternatives are available that meet the same goal. In contrast, market-based mechanisms create incentives for socially desired behavior but also permit some flexibility in how motorists respond (Giuliano and Wachs, 1992). For example, pricing expressways encourages individuals to shift travel to non-peak times or participate in carpools, but it also allows users to pay a premium if they so decide. Arguably, from an economics perspective, this is much more efficient as it allocates public road space by willingness to pay.

Although market-based instruments are more efficient than their command-and-control counterparts, the presence of political constraints makes them less politically feasible, and as such, they are less preferred compared to regulatory approaches (Santos et al., 2010). This compromise between economic efficiency and political feasibility is a common trade-off in transportation policy (Karplus, 2011). In addition, there is also concern about the fairness of allocating road space by willingness (or ability) to pay. For congestion pricing, an important debate is centered on efficiency versus equity, particularly since obtaining a suitable level of equity serves as a virtual prerequisite for public acceptance (see for instance Levinson (2010), Eliasson and Mattsson (2006), Schade and Schlag (2003), Viegas (2001), Langmyhr (1997) and Ulberg and MacFarland (1995)).

Despite the efficiency argument in favor of market-based instruments, it is important to note that regulatory approaches have other benefits associated with them, which could be used to achieve other objectives. For example, pedestrian zones or car-free centers have shown to improve the quality of public spaces, making it more enjoyable to walk around due to less noise and better air quality (Topp and Pharoah, 1994). Hence, while this thesis primarily focuses on congestion pricing, Chapter 4 briefly explores other command-and-control approaches, such as parking regulation and placing a quota limit on the number of vehicles allowed on the roads, as was applied in Singapore (Phang et al., 1996) and China (Chen and Zhao, 2013a).
2.3 Economic Fundamentals

2.3.1 A Basic Congestion Pricing Model

Congestion pricing is based on the remedy proposed by Pigou (1920) to the negative externalities problem: place a tax or levy on drivers to ensure that their perceived private costs are aligned with the true social costs of driving. The basic concept, as detailed in Button (2004) and Lindsey (2006), is briefly illustrated here using Figure 2-2. Road users are assumed to make one trip, with one person per vehicle, along a single stretch of road. The $x$-axis denotes the number of trips which are measured in terms of traffic flow (e.g., vehicles per hour), while the $y$-axis denotes the generalized cost of the trip $c$.

Costs go up as more motorists use the road. Individual road users only consider his or her private costs when making a trip, which will be equal to the average social cost $ASC(q)$ at a flow level $q$. Hence, the $ASC(q)$ is equal to the motorist’s marginal private cost $MPC(q)$, the cost the road user bears for traveling (Lindsey, 2006). The motorist’s willingness to pay to use the road is represented by the inverse demand curve $p(q)$, which is equal to the marginal private benefit $MPB(q)$ received for this trip. For the situation at hand, $MPB(q)$ is assumed to be equal to the marginal social benefit $MSB(q)$ (i.e., there is no marginal external benefit generated by the road user) (Button, 2004).
The equilibrium will be at \( A \), corresponding to a flow \( q_0 \) and price \( c_0 \), since this is where the \( MPB(q) \) and \( MPC(q) \) curves intersect. However, at \( q_0 \), the motorist enjoys the benefit of \( q_0 c_a \) but imposes a cost of \( q_0 c_b \) on society (Button, 2004). That is, at flow \( q_0 \), a marginal external cost exists, which is the difference between the \( MSC(q_0) \) the user imposes on society and \( MPC(q_0) \), the private cost already borne by the motorist.

An optimal congestion fee should account for the user's marginal external cost (Small and Verhoef, 2007). That way, road users not only weigh their own costs and benefits when deciding whether to drive through a congested area, but are now also forced to consider the additional costs they impose on other drivers. This internalization results in a more efficient allocation of traffic. Such a socially optimal outcome can be obtained by placing a congestion charge that raises the motorist's private costs \( MPC(q) \) up such that it now intersects the \( MPB(q) \) at a lower flow \( q_e \).

The congestion charge \( \tau \) can be obtained via the following (see Button (2004) and Lindsey (2006) for more details). For the scenario in Figure 2-2, the total social cost of \( q \) trips is

\[
TC(q) = ASC(q) \cdot q
\]

The marginal social cost of a trip can be obtained by taking the derivative of \( TC(q) \)

\[
\frac{\partial TC(q)}{\partial q} = ASC(q) + \frac{\partial ASC(q)}{\partial q} \cdot q
\]

The optimum \( \tau \) is equal to the marginal external cost of a trip, which is found by

\[
\tau = MSC(q_e) - MPC(q_e) = MSC(q_e) - ASC(q_e) = \frac{\partial ASC(q_e)}{\partial q_e} \cdot q_e
\]

Placing a charge \( \tau \) reduces the flow \( q_0 \) to a new equilibrium flow \( q_e \), where the road user's \( MPB(q_e) \) equals his or her \( MSC(q_e) \) on society. This also results in a welfare gain equal to the area of \( ABC \) due to the congestion reduction. Note that the formula for \( \tau \) is intuitive as it takes the cost imposed by each motorist on all other road users \( \frac{\partial ASC(q_e)}{\partial q_e} \) and multiplies it with the number of other drivers on the road \( q_e \) (Lindsey, 2006).
When prices are set to match the external costs generated by each road user, "first-best" pricing is achieved since this scheme allows for maximum economic efficiency (Lindsey and Verhoef, 2001). However, first-best schemes are of little practical use due to technological, public acceptability or other reasons (de Palma and Lindsey, 2011). Parry et al. (2007) also note the computational difficulties associated with estimating the marginal congestion costs on each road link. Furthermore, drivers may also be limited in their ability to respond to prices in real time. That is, varying the prices too often may overload the driver with information and undermine the objectives of CP. This problem is discussed further in Section 4.3.2. Hence, much work has focused on "second-best" pricing (e.g., cordon charging, peak versus off-peak pricing, etc.), which are less efficient but more practically relevant (see Section 2.4 for a review of these concepts).

I note that Figure 2-2 assumes generalized costs. This implies that the costs associated with other automobile externalities (e.g., air pollution, oil dependence, infrastructure damage, traffic accidents) can be accounted for through a Pigouvian tax. Hence, while this thesis primarily focuses on pricing traffic congestion, the framework presented in the following sections can easily be extended to include other externalities (e.g., CO₂ emissions). For a more detailed discussion on automobile externalities and pricing, see Parry et al. (2007).

2.3.2 The Tolled, the Tolled-Off and the Un-Tolled

Figure 2-2 illustrates the basic premise behind CP, but it masks some important issues with respect to congestion pricing’s impacts. To begin exploring these impacts, which is the focus of subsequent chapters in this thesis, I begin by introducing a paradox known as The Tolled, the Tolled-Off and the Un-Tolled (Zettel and Carll, 1964). The paradox, depicted in Figure 2-3, shows that implementing CP leads to all users being worse off than before.

Wohl and Hendrickson (1984) analyze the paradox by discussing the impacts on three groups of users: the tolled, the tolled-off and the un-tolled.

1. The tolled users are those whose marginal private benefit $MPB(q)$ is at least as high as $c_e$, which includes both the marginal private cost $MPC(q)$ borne by each driver and the congestion charge $\tau$. These users, to the left of $q_e$, pay the congestion charge and continue to drive since the benefits associated with their trips are still higher than the
Figure 2-3: An illustration of The Tolled, the Tolled-Off and the Un-Tolled.

total cost incurred. However, while the congestion they perceive does drop an amount equal to $c_a - c_d$, the drop is less than $\tau$. Hence, these users are now worse off than without the congestion charge.

2. The tolled-off are users whose $MPB(q)$ is lower than $cc$. These users, who are within the $q_0 - q_e$ range, will not pay the congestion charge and will instead choose another route or take another mode of transportation. The tolled-off are priced out of the road, and are also worse off than before since they are forced out of their original preferred option.

3. The un-tolled are not depicted in Figure 2-2, but constitute those users who are affected as the tolled-off drivers shift their travel patterns. For instance, the un-tolled could be transit riders or motorists who use alternate routes to the one that will implement CP. The un-tolled are made worse off as public transit or the alternate routes are made more congested once the tolled-off users divert to these options. This group could also include those who suffer indirectly, such as neighborhoods that experience an increase in rat running from drivers who try to avoid the charging zone (Jones, 2003).

The three groups of users above are all worse off after CP is introduced. Wohl and Hendrickson (1984) resolve this paradox by alluding to the role of revenue redistribution. That is, for pricing to be both beneficial to and accepted by the public, the revenues from
the congestion charges represented by rectangle $ECFD$ must be redistributed back to them to compensate their losses. Depending on the chosen technology, certain collection costs (shown as the smaller and darker rectangle within $ECFD$ on Figure 2-3) may erode away at the collected revenues, which limit the benefits that could be returned to the public. These issues are further discussed in the next section, as well as in Chapter 3.

2.3.3 Economics and Public Acceptance

As demonstrated by the paradox of the *The Tolled, the Tolled-Off and the Un-Tolled*, the increase in private costs need to be higher than the congestion-related benefits (e.g., lower travel times) in order to induce behavioral change. Thompson (1998) notes that:

> An important complication of road pricing is that there are a great many direct losers. Most affected vehicle owners will be, and must be, worse off because the (additional) price they pay must exceed the value of their congestion savings; otherwise there would be no traffic reduction. There will be some motorists who, valuing their time savings highly, will benefit, and some who, although prepared to pay the price, will feel that they are receiving too little for their money.

Motorists are likely to perceive themselves worse off. For instance, the reduction in vehicle operating costs may not be as visible compared to the congestion charge, which would be deemed a tax (Thompson, 1998). Hence, the collected revenues must be somehow redistributed back—perhaps through infrastructure improvements, transit investments, or some other lump-sum transfer—in order to leave the drivers better off than before (Lindsey, 2006). How the benefits are redistributed is one of many equity considerations important for any CP program. Section 2.5 elaborates on the relationship between economic efficiency and equity, and how both influence public acceptance.

In addition, the public acceptance of road pricing is affected by the support that could be rallied behind it. "Only severe awareness of congestion will lead to higher policy support," notes Albalate and Bel (2009), a notion they echo from Jones (1998), Schade and Baum (2007) and Steg (2003). In fact, Ison and Rye (2005) state that one of the reasons road pricing was rejected in Hong Kong was that congestion levels were not perceived to be
severe enough by the public to warrant such a policy. Drawing from the thoughts of authors from Richardson and Bae (2008), Anas and Lindsey (2011) hint that the lower congestion in New York City as compared to London might have influenced its public acceptance.

In fact, hypercongestion is often overlooked when conducting CP equilibrium analyses, which is shown in Figure 2-4 (Hau, 1992). Up to a certain point, adding traffic on a road increases the flow since the effect of more vehicles entering the link outweighs the road's reduction in speed (Button, 2004). However, as soon as the maximum capacity is reached, increasing traffic volume no longer offsets the speed reduction. This is known as hypercongestion, which is characterized by unstable stop-and-go conditions that can often lead to gridlock. The backward-bending portion of Figure 2-4 illustrates this concept. The hypercongestion case is often ignored in economic analyses (Button, 2004), but is surprisingly important since this is one situation where implementing congestion pricing can immediately make everyone better off (Hau, 1992). Arguably, as the severity of congestion approaches this magnitude, the argument to implement CP—and more importantly the public support behind it—increases substantially.

![Figure 2-4: The backward bending speed-flow function as a cost function. Adapted from: Button (2004).](image)

The objectives of the congestion pricing program also play an important role. Regardless if the message is to reduce congestion, help the environment, or raise revenues for transit improvements, the objectives of the CP program needs to be clearly stated to the public.
(Ison and Rye, 2005). This is important since CP can be viewed as a "revenue grab" in regions with little or no experience in tolling or pricing programs (Mahendra et al., 2012). It is also advantageous to link the CP objectives with regional goals (e.g., maintaining economic competitiveness) (Mahendra et al., 2012). Further evidence is provided by Jaensirisak et al. (2005), who use stated preference surveys to relate public acceptance to attitudes about congestion. The authors find that charging was more acceptable to those who perceive pollution and congestion as very serious issues. Similarly, Börjesson et al. (2012) report that how a congestion charge is communicated also affects its public acceptability, i.e., emphasizing the positive environmental impacts of CP can improve its public acceptance. In all cases, since CP requires generating substantial political support among both road and non-road users, a clear rationale must be established from the start that a radical policy like congestion pricing is appropriate for the problem at hand.

Rectangle $ECFD$, which represents the collected revenues, is simply a transfer from drivers to the operator. However, this necessitates the existence of a collection infrastructure that has associated operating, administrative and inconvenience costs to motorists (Lindsey, 2006). If the costs of collection are high, then the revenues and corresponding benefits are just eroded away. The next section reviews the available technologies that enable CP, and link the technological choice to its public acceptance.

2.4 Enabling Technologies

2.4.1 Program Mechanics

Existing technologies greatly enable the implementation of CP programs. However, the choice of technology is secondary to the decisions regarding program mechanics (e.g., type of pricing scheme, flat or dynamic prices, etc.) (de Palma and Lindsey, 2011). The Federal Highway Administration (FHWA, 2008c) considers four types of pricing schemes:

1. Variably priced lanes - fees on distinct lanes within a highway for low-occupancy vehicles to use high-occupancy lanes.

2. Variable tolls on roadways - tolls to use existing and new roads, bridges or other
facilities, often to pay for its construction or maintenance.

3. Zone-based charges - congestion charges are placed on motorists to drive within or into a congested area within an urban center.

4. Area-wide or system-wide charges - fees are levied on vehicles based on their type (e.g., car vs. truck), distance traveled (pay by $/km), time of day, power train (e.g., gasoline vs. hybrid) and other factors.

This thesis focuses on zonal-based charging, which shares some similarities with area-wide schemes. Zone-based charges have a few variations, which include cordon, area and zonal charging (FHWA, 2008c). In a cordon system, a fee is levied whenever a vehicle crosses a designated boundary around an urban center. For area charging, a charge is levied regardless if the trip originated from outside the boundary and then crossed it, or whether the trip originated from the inside. Finally, zonal charging is similar to a cordon system except that there are multiple, often smaller, cordons in and around an urban center where charges are imposed for crossing each of them.

The prices charged by CP programs could remain flat or vary dynamically throughout the day (Albalate and Bel, 2009). In the dynamic case, the charge is continuously adjusted according to traffic conditions: prices increase in peak times and decrease in off-peak times. Dynamic systems are more complex than using simple flat pricing schemes. However, there is usually a cap that guarantees drivers from not being overcharged a certain pre-set maximum limit (FHWA, 2008a). Depending on policy objectives, either pricing scheme may be more appropriate. For instance, if policy makers are only interested in smoothing out demand during peak hours, variable fees may be more suitable (Albalate and Bel, 2009). Conversely, a flat fee might be a better choice for areas that are congested throughout the day.

The scheme design has clear implications on the performance of the congestion pricing program. For example, Santos (2005) finds that a per-entry charge is more effective at mitigating traffic congestion than a per-day charge. On the other hand, having a scheme that is too complex can also have negative consequences. According to Gaunt et al. (2007), the complexity of the CP scheme is one of the reasons pricing was publicly rejected in Edinburgh. In addition, pricing schemes that are too complex or vary too often can reduce
the public's ability to adequately respond to these price signals (Balducci et al., 2011). These issues are further discussed in Chapters 3 and 4.

### 2.4.2 Congestion Pricing Technologies

Good program design is also contingent on the technology available, which enables the efficient enforcement of the congestion charge (Lindsey, 2006). For example, Singapore uses an Electronic Road Pricing system that involves time-varying charges that are automatically deducted from a pre-paid smart card every time vehicles pass the charging area (Xie and Olszewski, 2011). The FHWA (2008c) identifies the following technologies that enable CP: paper-based systems (PBS), manual-toll facilities (MTF), dedicated short-range communications (DSRC), vehicle-positioning systems (VPS), cellular, automatic license plate recognition (ALPR), and combination systems. Some discussions of each system follow.

Paper-based systems require motorists who intend to drive into a CP area to purchase and display a permit (e.g., a license displayed on the dashboard). In MTF, drivers often pay at a booth or plaza to enter the charge area. Both systems are less efficient than their modern counterparts (FHWA, 2008c). For instance, manual inspection is required to enforce PBS. On another note, the stop and go nature of manual payment for MTF causes additional congestion.

DSRC is the most commonly used technology for CP (FHWA, 2008c). The system requires that a) vehicles have an on-board unit (OBU), and b) the charging zone have roadside sensors along checkpoints that can communicate with the OBU. These sensors are usually mounted on gantries. Vehicle identification is done via the OBU, which enables the charge transaction to be handled electronically. The requirement of the OBU implies having a separate system handle users who do not have this technology. While a number of DSRC systems are currently being explored, two particularly interesting variants include infrared communications and radio frequency identification (RFID) (Ukkusuri et al., 2008).

VPS technologies, which include global positioning systems, do not require road infrastructure to locate a vehicle since they use satellites to determine its position. Hence, they have the benefits of wide area coverage with far fewer checkpoints (FHWA, 2008c). VPS provides more flexibility for authorities as it also allows the distance traveled for a vehicle
to be easily tracked. Cost is a major issue that limits this technology’s widespread adoption today. Using cellular networks to locate vehicles also remains a promising technology.

ALPR uses image recognition technology to identify vehicles who enter the charging area by license plate recognition. This technology has been most often combined with DSRC or VPS (FHWA, 2008c). In particular, ALPR is used when the vehicles that enter a congestion charging zone do not have the technologies needed for the DSRC or VPS to work.

Ukkusuri et al. (2008) attempt to systematically compare technologies that enable CP by proposing a framework that considers measures related to: economics (e.g., operating costs, technical life expectancy); operations (e.g., reliability, ease of enforcement); impacts, integration and flexibility (e.g., ease of integration with common payment methods); and other considerations (e.g., credibility of technology provider, data privacy). The authors conclude that RFID, a technology similar to DSRC, is the most promising to implement. Even though compared to DSRC, RFID has a more limited data transmission rate and range (e.g., under $0.10 per OBU). In addition, GPS could prove to be a beneficial choice for a primary system if issues related to cost, reliability and privacy are addressed.

2.4.3 Technology and Public Acceptance

Similar to economics, the main technology adopted to enable road pricing plays an important role in the program’s public acceptance. For instance, the London congestion charging program administered by Transport for London (TfL) is the only program that relies solely on ALPR technology (FHWA, 2008c), a costlier and less accurate system compared to DSRC (de Palma and Lindsey, 2011). Sole reliance on ALPR can be an issue since poor lighting or dirty plates could limit the effectiveness of the image recognition technology, which would then require manual inspection and raise costs (FHWA, 2008c). In fact, in 2005, the operating costs for the London congestion charging system was about 50% of revenues (Balducci et al., 2011).

Despite these issues, it could be argued that ANPR was indeed the more appropriate choice over DSRC from a public acceptance perspective. For one, former Mayor of London Ken Livingstone was determined to implement a congestion pricing program during his first term; hence, he opted for ANPR, which was a proven, reliable low-risk technology despite its
high infrastructure and operating costs (de Palma and Lindsey, 2011). Choosing a reliable system arguably minimizes the risk of any potential backlash from technological failures of the CP program. Indeed, "high levels of confidence in the technology" is one precursor to public acceptance (Ulberg and MacFarland, 1995).

In addition, the gantries to mount the DSRC sensors spanned the width of a road. This would not have been "sympathetic to the urban environment," and hence deemed environmentally unacceptable for a London setting (Kearns, 2006). Commin (2009) further argues in favor of TfL's decision. First, the author points out that it would have been too costly to equip the majority of London's daily motorists with an OBU, making ALPR more suitable since it did not require any on-board vehicle equipment. Second, since most schemes rely on a secondary ALPR system to support either DSRC or VPS anyway, upgrading to either of the two technologies would still put the ALPR system to good use (Commin, 2009). Both these reasons could be again viewed from a public acceptance perspective as the initial, operating and future costs of the program was under great public scrutiny (see for instance, GLA (2002)).

Having a transparent pricing scheme is also important for public acceptance (Herry, 2005). That is, the lack of transparency makes it difficult for the public to appreciate benefits associated with congestion pricing. Consider for instance that both the failed CP attempts in Manchester and Edinburgh proposed double cordon schemes, which are more complex that the single cordon schemes adopted in London and Stockholm. The effect of complexity on public acceptance is discussed further in Chapter 3.

Privacy is a technology related concern that influences acceptance (de Palma and Lindsey, 2011). Ison and Rye (2005) consider privacy to be one of the main issues that prevented Hong Kong from adopting a CP program since they viewed anonymity as a prerequisite for any scheme to be publicly acceptable. Similarly, a public engagement process in Washington D.C. finds that privacy is one of the major concerns against an area-wide pricing system (Swanson and Hampton, 2013). One way around this is to not keep track of records, but this may undermine the accountability of the system (de Palma and Lindsey, 2011).

So far, privacy has not been a concern for both London and Stockholm. In London's case, Ison and Rye (2005) suggest that this may be because of the public's acceptance to
closed-circuit television cameras. This acceptance of any privacy intrusion is likely grounded in people getting accustomed to using electronic systems (e.g., the internet), where it may be possible to track their behavior (PROGRESS, 2004). Mahendra et al. (2012) report that this may also apply for the United States: "[a]lthough privacy has been raised in opposition to congestion pricing schemes, it is typically not the primary issue of concern."

In addition to public acceptance, Levinson and Odlyzko (2008) also discuss how the choice of technology impacts how users respond to the system:

"The lesson for cases such as the London congestion charge is that when the aim is less to collect revenues and more to discourage usage, making the charges more intrusive is likely to be desirable. There should be no monthly passes or other easy payment methods. Requiring some positive action (involving heavy mental transaction costs) from the user, such as having to send an email or SMS message to the toll agency ahead of time, may discourage use as much as the magnitude of the toll itself."

Nevertheless, it is important to remember that some adequate level of revenues still need to be generated and redistributed in order to offset the losses of key groups. The relationship between congestion pricing and transportation revenues is further discussed in Section 4.3.1.

There is an interesting current development related to both CP technology and public acceptance. A CNN report (Valdes-Dapena, 2014) documents the National Highway Traffic Safety Administration's exploration of mandating the installation of DSRC-based vehicle-to-vehicle (V2V) communications technologies for vehicles. While the intended application of this V2V technology is safety, there are mobility benefits associated with it (NHTSA, 2011). With respect to CP, mandating vehicles to possess on-board DSRC technology could facilitate the implementation of a CP program (i.e., vehicles would be technologically enabled to support programs under different pricing schemes).

Designing the technical details of a CP program is only half the battle, and it is arguably the less challenging part. Public acceptance and political constraints also need to be met for a program to be implemented, with equity often being a central topic.
2.5 Equity Considerations

2.5.1 Defining Equity

Minimizing inequity is crucial to getting road pricing programs implemented (Ison and Rye, 2005). Since the perception of equity is affected by the distribution of CP's benefits and costs and externalities across society (Langmyhr, 1997), maintaining an equitable distribution of impacts is critical. Levinson (2010) lists the following dimensions in which equity can be examined with respect to road pricing:

1. horizontally across individuals within a class (e.g., income, gender, ability, race);
2. vertically across individuals from different classes (e.g., low versus high income);
3. spatially or territorially across geography (Viegas, 2001);
4. longitudinally (e.g., from the present across the future generations) (Viegas, 2001);
5. market equity (whether the benefits are proportional to the price paid); and
6. social equity (whether the benefits are proportional to need) (Jones, 2003).

In addition, there is also the concept of modal equity (FHWA, 2008b): "[a]re public perceptions with regard to encouragement of multi-modal transportation addressed?" For instance, it may not be fair to offer travel time benefits to those willing to pay to use high-occupancy toll lanes when other commuters act in more socially beneficial ways, such as taking transit or carpooling.

Vertical equity considerations have been more of a focus by the FHWA (2008b). For example, since the expected response from pricing is for motorists to shift modes and use transit, there is concern as to whether CP may make it more challenging for low-skilled workers to commute to work, assuming that these low-skilled jobs are not well served by transit (FHWA, 2008b). Based on data from the Netherlands, "it is found that lower incomes are more likely to have a fixed (determined by the employer) work start time," and hence may likely be less flexible in responding to congestion pricing (Emmerink and van Beek, 1997). In addition, even if transit options exist, the service may not be operating during...
off-peak times which is when these low-skilled jobs are often required (FHWA, 2008b). Some users may also be forced to pay the charge when no other suitable options exist (e.g., drive 20 minutes and pay the toll versus 60 minutes taking transit). This structured response due to the lack of alternatives exacerbates the inequity concerns brought by CP.

2.5.2 Equity and Congestion Pricing

There is still quite a bit of debate on the net equity impacts of CP (see for instance Levinson (2010) and Ecola and Light (2009)). This is partly clarified by a review of the literature conducted by Levinson (2010), which suggests that equity outcomes are context specific. That is, whether CP is progressive or regressive depends on the type of pricing scheme, definition of equity used, and assumptions about revenue redistribution.

Small (1992) points out that the revenues raised by congestion fees become central to handling equity issues. For instance, redistributing this revenue can be an effective means to lessen some of the resulting inequalities due to CP, i.e., they can be used to compensate the losers from this policy. Ecola and Light (2009) support the notion that the equity impacts are context specific, and caution transferring study results across different projects. For instance, whether cordon-based pricing programs are spatially equitable depends on where people live and work, in addition to how the cordon is laid out. Similarly, a program can be viewed as progressive if the benefits are redistributed, but regressive if only applied as a tax (Ecola and Light, 2009).

Further evidence of context specificity is provided by Eliasson and Mattsson (2006) who attempt to model the equity effects of road pricing in Stockholm. They conclude that the initial travel patterns and how the revenues are redistributed contribute the most to the net equity impacts of a pricing program. Their modeling results indicate that men, high-income groups and inner-city residents are affected the most, while women and low-income groups benefit greatly when revenues are invested to improve transit. If tax cuts are instead provided instead of transit improvements, high-income groups benefit more. Based again on numerical simulations, Armelius and Hultkrantz (2006) also show that a great fraction of Stockholm commuters benefit overall if revenues are reinvested towards public transport.
2.5.3 Equity, Revenue Redistribution and Public Acceptance

Levinson (2010) notes that CP's "political acceptability depends very much on the distribution (and perception of the distribution) of gains and losses to a proposed change." Hence, equity considerations are central to public acceptance. Any serious discussion of road pricing requires attention to how the revenues are used. This becomes particularly important when consensus building is sought (Goodwin, 2004). To improve public acceptability of CP, hypothecating the collected revenues to transportation improvement projects is often necessary. Jones (2003) emphasizes that this money should be in additional to what would have been spent on this area. A review of international evidence by (Lyons et al., 2004) reaffirms this notion.

Many pricing authorities assert that specifically investing the collected congestion fees in mass transit is central to public acceptance and successful implementation. For instance, a survey of Edinburgh residents found that voters were more in favor of CP schemes that diverted revenues to bus service improvements (Farrell and Saleh, 2005). Furthermore, if no viable transport alternatives exist (e.g., poor service or non-existent transit), upfront investments are often needed before the public even begins to consider CP (Jones, 2003). This revenue redistribution towards public transportation also favors low-income groups who are usually more dependent on mass transit (Viegas, 2001). Hence, revenue recycling is also a means to reduce some of the vertical inequitable impacts of road pricing. In addition to addressing these concerns, diverting revenues to public transit provides a viable alternative to the automobile. This limits the utility loses for drivers who switch, which improves society's overall welfare.

One possible concern with regards to hypothecating CP revenues to public transit is that it may go against the user pays principle that has guided transportation funding in the United States. For highways in particular, "[u]users agree to pay fees with the understanding that the agency will spend the revenue to provide highway services" (TRB, 2006). Using motorists' payments to subsidize transit users runs against this mentality. However, Antos (2007) finds that the structure of transit subsidies in Chicago can disproportionately benefit motorists who receive more congestion savings than what they have paid. Hence, hypothec-
cating CP revenues to transit can arguably benefit most, if not all, users of the transportation system. An alternative is to redistribute the revenues to a larger base of citizens through tax reductions or other rebates, instead of public transit hypothecation. This may be more politically popular since the revenues are returned to a larger user group (Litman, 1996).

While revenue hypothecation—particularly towards transit—is important for public acceptance, a larger issue appears to be about choice (Swanson and Hampton, 2013):

A sense of choice seems vital to cultivating public support for congestion pricing. Many participants [of the public engagement process] said that because driving is not a choice for most people, pricing should be. The availability of other options besides driving—such as transit, walking, and biking—increased receptivity to pricing. Participants also spoke favorably of proposals that would maintain non-tolled lanes or routes for those who cannot or do not want to pay.

Hence, ensuring adequate alternatives exist (e.g., public transit) before the introduction of any road pricing program is a way to reduce equity issues and improve public acceptance. In London, supplementary measures that accompanied the CP program include increased bus services and the retiming of traffic signals (Anas and Lindsey, 2011). In Stockholm, the congestion charging trial was packaged with new bus lines, service extensions across bus and rail, as well as new and improved park-and-ride facilities (Anas and Lindsey, 2011). Though, it is worth noting that a public transport agency may require a certain lead time to improve transit service (e.g., new bus routes), which could impact when CP is introduced. In London’s case, 200 extra buses to serve the cordon area were operational by CP’s introduction in 2003 (Banister, 2003), but this might have been enabled by London’s privately operated bus service.

2.6 Economics, Technology and Equity

2.6.1 A Unified Framework that links Economics, Technology and Equity

Throughout this chapter, I draw linkages across economics, technology and equity and show that they collectively influence public acceptance. However, as touched on in earlier sections,
tensions also exist across these three dimensions. The following quote from de Palma and Lindsey (2011) illustrates how these three considerations could be in conflict with each other with respect to CP:

This brief review of the theory of CP reveals that congestion tolls should be differentiated by vehicle type, road link, time of day, real-time traffic conditions, trip purpose, and local conditions such as pricing of public transit services and other substitute modes of transport. In practice, tolls cannot be freely varied along all these dimensions. For technological, economic, or public acceptability reasons it may not be possible to toll all roads, to adjust tolls frequently by time of day, or to vary tolls according to traffic conditions.

I synthesize the ideas discussed in this chapter through Figure 2-5. Economics, technology and equity are linked to each other and collectively influence public acceptance as depicted by the lines inside the triangle. In addition, trade-offs are also required across these three dimensions as depicted by the outer triangle.

Figure 2-5: A unified view of the economic, technology and equity dimensions of congestion pricing.
First, while congestion pricing is an idea grounded in economics, its success is mainly moderated by the public perception of the problem, which in turn determines the political support generated for the program. As shown by the example of Hong Kong, the congestion problem needs to be perceived severe enough by the public before a pricing program is warranted (Ison and Rye, 2005). The objectives of the program also need to be clearly stated (Ison and Rye, 2005). In addition, revenue redistribution becomes key in order to compensate users who incur losses from the congestion charges (Lindsey, 2006).

Technological choice is also an important factor that affects public acceptance. For one, transparent schemes and technologies are important. Furthermore, Bhatt et al. (2008) report that "[t]ransparency in pricing planning and decision making also will enhance acceptability, including the degree to which non-pricing options have been examined; and the extent of reference to pricing experience elsewhere." There are also situational constraints which need to be respected. In London's experience, the large towering gantries needed to support efficient DSRC technology were not acceptable to London's urban environment (Kearns, 2006). Situational constraints also extend to the context of the situation (e.g., data privacy in the case of Hong Kong (Ison and Rye, 2005) or technological reliability in the case of London (de Palma and Lindsey, 2011)).

With respect to economics and technological choice, a trade-off between feasibility and efficiency is made since the economic efficiency of CP programs are constrained by the available technology. For instance, distance-based charging as implemented in area-wide or system-wide schemes offer efficiency benefits since they price close to marginal cost. However, not only do they pose technological challenges (de Palma and Lindsey, 2011), but there is also concern of whether these schemes are too complex for the public to understand. Recall that the complexity of the Edinburgh's scheme did not help its acceptance (Allen et al., 2006). The initial and operating costs of the program, which are in large part due to the technology choice, also affect acceptance (see for instance the case of London (GLA, 2002)).

Equity is the final consideration for public acceptance examined in this chapter. While congestion pricing is arguably socially beneficial from an economics perspective, its impact on individual equity is a very important consideration. Hence, as is extensively discussed in the literature, there is tension between economics and equity where the main trade-off is
between that of social and individual welfare.

The context specific distribution of benefits and costs then become paramount in any discussion about acceptance (Levinson, 2010). This is particularly important since who wins and who loses can motivate actors to support or oppose the program. This idea is further explored in Chapter 3. Redistribution serves as a tool to manage equity considerations, in which the availability of transport alternatives become key (Jones, 2003). Whether it is transit, biking or non-tolled lanes, providing people choices improves public acceptance (Swanson and Hampton, 2013), and reduces the possibility of any forced behavioral response (i.e., pay the charge due to the lack of adequate alternatives). In addition, reinvesting revenues towards public transportation helps low-income households dependent on mass transit, who arguably are also more affected by the implementation of CP (Viegas, 2001).

With respect to technology and equity, a balance needs to be maintained between system efficiency and user costs. For instance, as argued by Commin (2009), it would have been too cost prohibitive to equip every London motorist with an OBU; hence, adopting the ALPR technology was more appropriate for the city. While it would be possible to shift this cost to the user (i.e., provide incentives for motorists to purchase OBU themselves), there are still equity issues with respect to households that "do not have credit cards, bank accounts, or cannot afford large deposits" (FHWA, 2008b). On the other hand, technological inefficiencies in revenue collection can also erode away the collected benefits of the CP program (e.g., the 2005 operating costs for the London CP program was about 50% of revenues (Balducci et al., 2011)), which then degrades the efficiency of the redistribution.

2.6.2 A Deeper Look into Public Rejection

This chapter reviews the economic principles, existing technologies and equity considerations that underpin road pricing. I show that the three not only affect CP's public acceptance, but that they can be in tension with each other at times, and often call for trade-offs to be made among them. Throughout the chapter, the issue of equity has emerged to be a central consideration, along with the public's perception of the problem and understanding of the pricing program. The next chapter explores these ideas further, taking a more focused perspective on the public rejection and political failures of congestion pricing.
Chapter 3

Sources of Public Rejection: Inequity, Uncertainty, Societal Views and Institutional Issues

3.1 Chapter Overview

In this chapter, I introduce a new framework that roots the public rejection of congestion pricing along the dimensions of inequity and uncertainty, influenced by societal views and institutional issues. Using this framework, I pose the political problems of collective action, credible commitment, free riding and loss aversion as specific combinations of perceived inequity and uncertainty. I then show that societal views also play an important role by moderating the public's sentiment about pricing. Afterwards, I link the framework to institutional issues, particularly the political process that could constrain and block the approval of a CP proposal. The chapter concludes by applying this framework to analyze the failures of New York, Manchester, Edinburgh and Hong Kong in implementing congestion pricing, and presenting solutions to these challenges.

3.2 Public Acceptability of Congestion Pricing

3.2.1 Public Acceptance and Political Failures

Anas and Lindsey (2011) note that the "lack of public acceptance has been the most important barrier to road pricing schemes." Congestion pricing necessitates charging users, and as such, it is politically unpopular and challenging to garner major support for among motorists.
(Schade and Baum, 2007). This is confounded by the fact that virtually all motorists are voters. Hence, in addition to analyzing the supporting economics, technological design and equity considerations of a CP program—as discussed in Chapter 2—there are still a number of political obstacles that must be navigated before CP programs have a good shot at successful implementation.

The political challenges are evident from the experiences of transport authorities that have attempted to introduce CP. For instance, a CP program has been successfully introduced in London, partly due to strong government support and the hypothecation of revenues towards improving public transit (Santos and Fraser, 2006). The latter two conditions also existed in Edinburgh and in Manchester, but both encountered very strong opposition and were rejected by public referenda (Rye et al., 2008, Ahmed, 2011). In New York City, the congestion charging proposal was still voted down in 2008 despite the strong political backing of Mayor Bloomberg and over $300 million of federal money (Schaller, 2010).

The examples above suggest that introducing congestion pricing may be politically viable, but there are instances when public acceptance and the political process control the outcome. Hence, it is useful to take a closer look on why CP was accepted in some jurisdictions but rejected in others. In this chapter, I explore possible reasons why CP fails to get publicly accepted, even when it appears that certain "best practices" (e.g., revenue hypothecation) have been followed. Since the successful implementation of congestion charging rests on multiple issues (e.g., public support, implementation agency, having a political champion, etc.) (Ison and Rye, 2005), this chapter builds on ideas from Chapter 2 by dwelling deeper into the relationship between political feasibility and public acceptance of congestion pricing.

3.2.2 Factors Affecting Political Feasibility

Karplus (2011) proposes a list of factors that affect the political feasibility of gasoline taxes. Due to the high similarity between gasoline taxes and congestion pricing (they are both market-based mechanisms), this thesis applies her analysis to the problem at hand. In addition to equity issues discussed in Chapter 2, Karplus (2011) considers three other criteria in examining political feasibility: ideology, ease of implementation and political process constraints. These are discussed below:
1. Ideology. Some politicians will not support any sort of road pricing scheme purely based on principle alone. Here, issue-based stances like energy security, environmentalism and freedom of mobility become central. In particular, whether pricing is perceived to be progressive or regressive can affect politicians’ stance on this policy (Levinson, 2010). This is further compounded when political ideology influences public acceptance of CP. This was evident in the case of Stockholm where voters aligned with the positions their political parties maintained about the introduction of CP (Härsman and Quigley, 2010).

2. Ease of implementation. Policies that require coordinating diverse groups with disparate interests could be very challenging. According to Rye et al. (2008), this was the case in Edinburgh where the surrounding local authorities felt that the proposed scheme charged their residents, but allowed City of Edinburgh residents to drive free. New York City experienced a similar obstacle (Schaller, 2010). This has been partly addressed by the CP literature which stresses the importance of a single implementing agency to maximize the chances of success Ison and Rye (2005).

3. Political process constraints. Election cycles, institutional structures, and policy processes place constraints on the type of policies that get approved. Having different political levels can also become an important obstacle in getting a CP program implemented (Albalate and Bel, 2009). For instance, implementing congestion charging in New York City and Edinburgh required the final approval of the State Assembly and National Minister respectively, in contrast to London where the final decision was up to the Mayor (Schaller, 2010, Rye et al., 2008). Strong political opposition in both New York City and Edinburgh effectively killed the proposals by achieving a veto of the final decision.

Economically efficient solutions, such as congestion pricing, often do not meet these political constraints, and the same attributes that make them cost-effective also reduce their political feasibility (Karplus, 2011). On the other hand, regulatory policies discussed in Section 2.2.3 are more amenable to consumers on the basis of their perceived value and primary goal. For example, motorists might see a congestion charge as a tax grab and not an
effective policy instrument to reduce automobile externalities. In comparison, regulations like "odd and even" license plate systems communicate a more transparent and direct message.

The third point Karplus (2011) raises, political process constraints, is particularly important since the political process is the avenue in which opposition for CP is operationalized. For instance, the public's concerns about the effectiveness of road pricing in both Edinburgh and Manchester manifested in their voting against its introduction via public referendum (Hensher and Li, 2013).

3.2.3 Factors Affecting Public Acceptance

To better elicit the relationship between political feasibility and public acceptance, previous work on the acceptability of road pricing is briefly reviewed. Börjesson et al. (2012) note that "while political acceptability is influenced by the level of public acceptability, public acceptability is neither a necessary nor a sufficient condition for political acceptability." Nonetheless, the case studies examined in this chapter show that public acceptance (or rejection) of CP significantly affects its chances of getting implemented.

Schlag and Teubel (1997) present a comprehensive list of factors that influence the public acceptability of transportation pricing schemes: problem perception; perceived effectiveness and efficiency; equity; revenue allocation; mobility related social norms; important aims to reach; awareness about options; and attribution of responsibility.

Many of these factors have already been touched on in Chapter 2. For instance, problem perception describes how the traffic problem is perceived. This factor suggests that the congestion must be severe to be warranted, as in the case of Hong Kong (Ison and Rye, 2005). Congestion pricing must then be perceived as an effective and efficient solution to the congestion problem. Equity considerations have also been discussed, as well as using revenue allocation to manage equity concerns. I point out that uncertainty about the program, such as whether revenues will be redistributed back to the public, affects acceptance.

Important aims to reach denote the objective of the CP program (e.g., reducing congestion, raising revenues, etc.), which may be in conflict with each other. For instance, with respect to mobility, some societal aims (e.g., use of transit) can compete against personal aims (e.g., use of automobile freely) (Schade and Schlag, 2003). Mobility related social norms
pertain to the effect of social pressure to accept measures such as CP. There must also be awareness about options, i.e., transparency in pricing planning and decision making is critical so that motorists understand the background of the problem, the goals of the CP program, as well as its concrete realization. The last factor, attribution of responsibility, suggests that people would agree more with CP if they consider themselves partly responsible for the congestion problem (Schlag and Teubel, 1997).

3.2.4 Review of Empirical Evidence

Schade and Schlag (2003) evaluate the factors proposed by Schlag and Teubel (1997). Using a survey of motorists across four European cities (N = 952), they find that mobility related social norms, personal outcome expectations (i.e., equity) and perceived effectiveness and efficiency are positively related with road pricing acceptability. These factors also account for 40% of the variance that explains acceptability. Note that equity is operationalized as personal outcome expectations, which pertain to the personal advantages gained by individuals when CP is introduced. The results of Schade and Schlag (2003) suggest that social pressure to accept CP can be a useful mechanism to aid in its introduction. In addition, the survey results corroborate held beliefs on the importance of equity. This suggests the need to communicate the costs, benefits and equity impacts of CP in a credible and convincing manner. Doing so would not only manage personal outcome expectations, but would also ensure that the public views CP as an effective solution to congestion.

Related evidence is provided by Eriksson et al. (2008) who examine the acceptability of push (e.g., gas tax) and pull (e.g., improved transit) transport policy measures. They survey car users in Sweden (N = 827) and find that pull measures were perceived to be fair, effective and acceptable, while opposite sentiments were felt for push measures. Individual problem awareness was found to directly influence the acceptability for pull measures, while personal norms influenced the degree to which push measures were accepted. Similar to the results obtained by Schade and Schlag (2003), Eriksson et al. (2008) find that perceived fairness and effectiveness were important factors for acceptability.

Schuitema et al. (2011) present a different perspective. They survey an average-sized city in the Netherlands (N = 101), and find that the fairness and acceptability of transport
pricing policies are higher if the outcomes equally affect everybody and are deemed to be beneficial for society (e.g., protection for future generations and nature). This suggests that focusing on the collective implications, as opposed to individual interests, might be helpful in getting transport policies implemented. This runs contrary to results of a public engagement process in Washington D.C., which find that "participants said that fairness mattered, but it does not appear these concerns were pivotal in determining levels of support for different congestion pricing scenarios. However, many people did express concerns about whether pricing would be fair to them personally" (Swanson and Hampton, 2013).

Schade and Baum (2007) survey motorists on German motorways ($N = 140$) and find that users who are convinced that a toll will be implemented are more accepting of road pricing as opposed to those who are less convinced. In addition, they find that individuals who were under the impression that pricing is inevitable do not only develop more positive attitudes towards it, but also have lower negative emotions (e.g., anger).

Based on a road pricing experiment in Copenhagen ($N = 517$), Gehlert et al. (2011) find that socioeconomic factors (e.g., age, household size and composition, income and car use) affect the adaption towards road pricing and the preference for how the revenues are used. They segmented their respondents into three groups (young families, suburban families, as well as singles and couples), and find that the three groups did not have any statistical difference in terms of their acceptance of road pricing. However, while the three groups all reduced their auto usage significantly, young families reduced their car usage the most.

While the authors above primarily draw their conclusions from European data, I believe that their findings are still useful and can inform U.S. jurisdictions interested in introducing CP. I consider the following of particular interest going forward:

1. The perceived fairness and effectiveness of a road pricing program are important factors for its acceptability. As such, communicating the purpose, mechanics, costs and benefits of the CP program effectively becomes a prerequisite for its acceptance.

2. The public’s preconceived notion on the definitiveness of CP’s introduction is also another consideration. This further supports the need for a strong campaign to shape public opinion on CP since positive feedback may exists that could help reinforce the
acceptability of CP. For instance, once a positive public view on congestion pricing achieves a relative majority, opposing individuals may be convinced of its inevitable introduction and be more accepting of it.

3. Societal norms and social considerations also play important roles. Hence, adopting a strong campaign to shape the public view on the importance of congestion pricing can be a very useful tool to help in its introduction.

3.3 Inequity, Uncertainty and Public Rejection

3.3.1 Public Rejection due to Inequity and Uncertainty

The political economy of congestion pricing has largely centered on the distributional implications of this policy (Small and Gómez-Ibáñez, 1998). Based on a review of recently failed road pricing proposals, I reiterate that addressing concerns about inequity is critical to public acceptance. For instance, the most vocal opponents of the road pricing proposal in New York City were from the outer boroughs, which are areas outside the proposed cordon charging area (Manhattan). Specifically, these opponents come from Queens and Brooklyn, which were relatively auto-dependent and had the least convenient transit access to Manhattan jobs (Schaller, 2010). Arguably, the opposition for CP in New York City could be largely rooted in modal and spatial inequity concerns.

I also assert that uncertainty can be detrimental to acceptance since any doubts of a program's benefits can reduce peoples' willingness to pay for the policy in the present. For example, residents from both Manchester and Edinburgh did not trust that their governments would deliver the transport investments that were promised from the congestion fees (Manville and King, 2012, Rye et al., 2008). That is, their residents did not want to incur present costs for uncertain future benefits, which were rooted in the lack of trust in their governments. Uncertain future benefits can also compound residents being averse to losing a free good (e.g., roads) today for some benefit (e.g., less congestion) tomorrow (Kahneman et al., 1991).

Frameworks to analyze the public acceptance of CP through the lens of inequity and
uncertainty have been previously proposed. However, to the best of my knowledge, no works have attempted to root these failures by combining frameworks based on both. Before I introduce a new framework that is based on both inequity and uncertainty, I review previous works related to these topics.

### 3.3.2 Existing Inequity and Uncertainty Frameworks

Raux and Souche (2004) put forward a framework for analyzing the public acceptability of road pricing that is based on Rawls' theory of justice. Their approach unites economic efficiency, spatial equity, horizontal equity and vertical equity. They intended their work to complement an existing political economy framework of Oberholzer-Gee and Weck-Hannemann (2002) by attempting to quantify different equity dimensions in order to compare various pricing schemes. They employ a four-step travel demand model to conduct their analysis. Accessibility measures computed from the model are used to quantify spatial equity changes. Changes in user surplus as estimated from travel times and costs serve as the proxy for changes in horizontal and vertical equity. They apply their framework to a case study of an urban toll in Lyon, and show how certain measures that restrict traffic on roads could negatively impact all three dimensions of equity simultaneously. This then leads to the public rejection of the CP scheme.

De Borger and Proost (2012) and Marcucci and Marini (2003) both consider the role of uncertainty on public acceptance using economic models and simulated toy examples. De Borger and Proost (2012) build a simple majority voting model for introducing urban CP, and show that individual uncertainty with respect to the costs associated with switching transport modes deter public acceptance of a CP program. In addition, the authors demonstrate that political uncertainty about the benefits of the program (e.g., when it is not clear how the collected revenues will be used) further decreases support for CP. In line with conventional thinking, their model also predicts that: 1) there is more support for CP when revenues are used to subsidize public transit; and 2) attitudes towards pricing are more positive after, rather than before, its introduction. Both results show how resolving uncertainty with respect to CP's impacts can help garner more support for it.

Marcucci and Marini (2003) also develop an economic model for the political feasibility
of road pricing. Their approach considers the role of individual specific uncertainty in explaining the public acceptance of CP. Their model is also able to demonstrate the value from reducing the uncertainty individuals have regarding the evaluation of a public good (e.g., environmental quality). For one, when there is a strong presence of information campaigns that support environmental goals, their model predicts an increase in public support for congestion pricing.

Raux and Souche (2004) validate the notions discussed earlier regarding inequity's negative impact on the public acceptance of CP. On the other hand, the models of De Borger and Proost (2012) and Marcucci and Marini (2003) show that while uncertainty can undermine any promised benefits of a CP program, there are a number of ways uncertainty could be resolved (e.g., revenue hypothecation, pilot projects, public communication, etc.) to help further support the introduction of a congestion pricing program.

3.3.3 Types of Political Obstacles

While inequity and uncertainty can be viewed as causes for the public rejection of CP, the rejection itself manifests through political barriers. In particular, previous authors have suggested that the political feasibility of congestion pricing is vulnerable to problems of collective action (Albalate and Bel, 2009, Schaller, 2010), loss aversion and free riding (King et al., 2007), as well as credible commitment (Manville and King, 2012). This thesis presents a view that roots these political obstacles as specific combinations of perceived inequity and uncertainty. Before this new framework is introduced, I briefly review these suggested political problems in the context of introducing congestion pricing.

Albalate and Bel (2009) recognize that congestion pricing is prone to the problem of collective action (Olson, 1963) since the benefits of a CP program are usually widespread and shared across a large body of individuals, while the costs are often concentrated on small groups. Hence, Albalate and Bel (2009) note that the "[a]dversely affected groups are easily organized and often rally against the project, while the group of beneficiaries usually remains more passive." For instance, motorists shoulder the direct costs of CP but share its benefits (e.g., less congestion, better air quality, etc.) with virtually all other urban area residents. Motorists who are opposed to CP are more easily organized to rally against its
implementation. This was the case in New York City where small interest groups outside of the proposed charging zone played a significant role in blocking the introduction of CP (Schaller, 2010).

Even when both benefits and costs are dispersed across the population, King et al. (2007) claim that CP will still be difficult to introduce precisely because there is no constituency who will derive concentrated benefits from CP's implementation. That is, there will be no strong advocates for CP since the benefits of the program do not outweigh their political costs. Hence, "[a] free rider problem emerges: even if most drivers think they would be better off with congestion tolls, no one will be so much better off that they will take the lead to implement the program" (King et al., 2007). The authors refer to Machiavelli's The Prince in explaining the difficulty associated with "the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old order of things, and lukewarm defenders in those who may do well under the new."

To combat this situation for the case of highway tolls, the authors suggest to return toll revenues to cities with freeways. Concentrating the benefits would put elected officials from these cities in positions to gain considerably, and hence lobby for CP's implementation. I note that while this may be a pragmatic solution, it may not be fair. In particular, if the highway users are not constituents of the city, they might not receive the redistributed benefits since these would be controlled by the city.

King et al. (2007) further argue that loss aversion poses an additional political barrier to the introduction of CP. Loss aversion occurs when the disutility of losing a benefit is greater than the utility of acquiring (Kahneman et al., 1991). This implies that motorists will weigh the loss of free road access more than the benefits brought by the CP program (King et al., 2007). Furthermore, McFadden (2007) points out that people have an innate fear making choices, which makes them vote against market solutions (e.g., congestion pricing) and opting instead to keep the status quo.

Manville and King (2012) also pose a credible commitment problem that undermines any government promised future investment in the transportation system. For example, commitment problems can arise when the public distrusts the government's promise of hypothecating CP revenues towards transit. This often is because the party who makes a
commitment has reneged on similar promises in the past. Hence, Manville and King (2012) assert that demonstration projects, rather than revenue promises, can garner more political support since it can help overcome the credible commitment problem. Though, I caution that the temporary perception associated with demonstration projects can welcome political opposition against charging.

3.3.4 An Inequity and Uncertainty Framework for Analyzing Political Obstacles

The previous authors have considered political economy failures in the context of congestion pricing. I take their proposals and suggest that these problems arise due to specific combinations of the inequity and uncertainty about the costs and benefits of the CP program. The benefits of CP are geographically diffuse (e.g., less traffic for all motorists in the region), while the costs are usually more concentrated across some spatial groups. As discussed in the previous section, these conditions often lead to collective action. Small interest groups who are adversely affected are more easily organized to rally against the implementation of this policy (Albalate and Bel, 2009). These groups could be those who are directly impacted, such as commuters from outer regions who have no viable travel alternative and must pay the congestion charges. These could also include those who suffer the effects indirectly, such as neighborhoods that experience an increase in rat running from drivers diverting routes to avoid the new congestion charging zone (Jones, 2003).

Similarly, how the collected revenues from the congestion fees are spent is also a very important consideration (Button, 2006). For instance, individuals are usually more willing to accept CP when revenues are hypothecated towards transportation-related improvements (Jones, 2003). Investing in public transit is a medium that can benefit users who have access to it, and hence is often used to limit the resulting inequity from CP. However, when some motorists are excluded from this benefit, collective action is again likely to arise.

In New York for instance, the opposition to CP's introduction was "centered in eastern Queens and southern Brooklyn. These areas are more auto-dependent than neighborhoods closer to Manhattan and have the least rapid or convenient transit access to Manhattan jobs" (Schaller, 2010). In addition to spatial and modal inequity issues, some vertical inequity considerations also came into play. "Opponents viewed pricing as an attempt at social
engineering by primarily Manhattan-based elites.” In the end, the collective action of a small group of auto users is one of the reasons CP failed to get legislative approval in New York City (Schaller, 2010).

Even when individuals perceive a fair distribution of benefits and costs, the confidence the public has on the certainty of these future benefits is also important. Road pricing forces drivers to pay upfront costs for potential future benefits (e.g., transit improvements). Uncertainty that these benefits will materialize can derail efforts to introduce CP. In particular, the public may not believe that the government would deliver the promised benefits, leading to problems of credible commitment (Manville and King, 2012). In fact, credible commitment is one of the factors that led to the rejection of congestion pricing in both Manchester and Edinburgh via public referendum voting (May et al., 2009, Rye et al., 2008, Manville and King, 2012). Furthermore, the credible commitment problem can also be exacerbated by a general lack of trust in government. According to Swanson and Hampton (2013), public engagement participants "said they lack confidence in the government’s ability to solve transportation problems even if enough funding were available.”

Even when the public perceives the distribution of impacts to be fair and the benefits of the program to be certain, free riding is likely to occur since the benefits of CP are so diffuse that the general public would have no incentive to mobilize and support this policy (King et al., 2007). King et al. (2007) go even further and claim that motorists are likely to experience loss aversion in these situations. That is, there is this strong fear of loss for this once free good, which would outweigh any potential future gains (Albalate and Bel, 2009).

It is worth noting that drivers are often worse off before the collected revenues could be used to compensate those affected (André de Palma et al., 2006). Hence, I point out that when the benefits are not clear upfront, the visibility of the costs is likely to make the situation worse. Both loss aversion and credible commitment discount the future benefits of CP and cause motorists to be reluctant on parting with a benefit they already possess: driving on free roads. In Edinburgh’s case for instance, the public did not have confidence that sufficient alternatives to driving would have been put in place prior to CP’s introduction Rye et al. (2008). Contrast this with London where a large number of people were already in buses and were likely to benefit from the hypothecation of CP revenues.

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3.4 Societal Views and Institutional Issues

3.4.1 Societal Views as a Moderator of Public Acceptance

The previous section proposes a view that frames the existing political barriers of collective action (Albalate and Bel, 2009, Schaller, 2010), loss aversion and free riding (King et al., 2007), and credible commitment (Manville and King, 2012) as being rooted in specific combinations of perceived inequity and uncertainty. In addition to these two dimensions, I consider societal views to also play an important role.

This idea was first introduced in Section 3.2.4 through the work of Schade and Schlag (2003), which discuss the importance of mobility related social norms (i.e., societal pressure to accept congestion pricing) to the acceptance of pricing. Societal considerations also enter the equation, as shown by Schuitema et al. (2011). They provide survey evidence that shows a higher acceptability for transport pricing strategies where outcomes equally affect everybody and are deemed to be beneficial for society. My definition of societal views also includes the public perception about the proposed pricing scheme. As discussed in Chapter 2, the public perception of the congestion problem is a key factor that determines the political support generated for introducing CP. Recall that the congestion in Hong Kong was not perceived to be severe enough by the public, which then led to the rejection of CP’s introduction (Ison and Rye, 2005).

Similarly, how the media portrays pricing also helps shape public opinion on the matter, which then influences acceptability. In Manchester for instance, the media focus was on the charging element, with little attention paid to the transit investments that are part of the CP package (Vigar et al., 2011). Hence, adopting a strong campaign to shape the public view on the importance of congestion pricing can be a very useful tool to help in its introduction. While inequity and uncertainty are important considerations, I argue that societal views affect public acceptance by moderating these two factors. If the general public opinion, including the media coverage, recognizes congestion pricing as necessary for the greater good, then there will be more pressure on individuals to accept CP (Schlag and Teubel, 1997). Consequently, the public may view this policy as more equitable, and doubt its associated benefits less.
3.4.2 Need for Political Champion

In helping shape the public opinion on CP, the presence of a political champion can be significantly advantageous. The need for a leader to champion the introduction of CP is well documented in the literature. Ison and Rye (2005) state that:

It could be argued that a policy champion or protagonist dedicated to the task of implementation is vital in terms of road user charging. The implementation of road user charging will involve a diverse range of stakeholders in a fragile alliance and, as such, a policy champion that can provide leadership and direction is required.

For example, the lack of a strong political leader is one of the reasons congestion pricing failed to be introduced in Edinburgh and Manchester (Samdahl et al., 2013). In the former, the decision was up to the Scottish Executive and national Minister in Scotland, who had no local interest in the matter (Samdahl et al., 2013). In the latter, division among the local leaders in Manchester resulted in a lack of commitment to the implementation of CP. Swanson (2009) reports that "[f]rom the beginning, the commitment of Manchester's leadership to road pricing seems to have been lukewarm... This lack of commitment to the concept of road pricing may have doomed it from the start."

3.4.3 Organizational Challenges

The lack of a political champion is partly related to the organizational structure of various jurisdictions. Here, cooperation across various agencies become paramount, which point to the need to form strategic alliances across a variety of public and private stakeholders (Samdahl et al., 2013). This coordination issue was earlier identified through the work of Karplus (2011), who relate the ease of implementation of a policy with coordinating the different actors who possibly have disparate interests in the matter. For instance, Mahendra et al. (2012) notes that the "allocation of both the costs of constructing priced facilities and allocation of revenues among jurisdictions, constituencies, and modes (e.g., transit, roadways) can be contentious issues." It doesn't help that there can often be silos between
and within the different agencies involved, with cultural differences that might divide them (Mahendra et al., 2012).

A central issue is who controls implementation. Ison and Rye (2005) report that a single implementation agency is useful to address some of these organizational issues. They note that the need to coordinate across various political jurisdictions caused further complexity in implementing CP in both Edinburgh and Hong Kong.

New York City experienced similar challenges with respect to its organizational structure, primarily due to the separation of power between NYC's political champion for CP, Mayor Bloomberg, and the Metropolitan Transportation Authority. Samdahl et al. (2013) summarize this organizational issue and relate it to the problem of uncertainty discussed earlier:

While the city led a strong multi-agency working group including city, State and transit agencies, the Metropolitan Transportation Authority (MTA) would have spent the money. Despite a 'lockbox' provision in the proposed authorizing legislation, many questioned whether the revenues would be spent as intended, undercutting support for the plan.

3.4.4 Legislative Structure and the Political Process

Despite having a political champion, as well as positive press and public reaction towards the introduction of CP in New York City, Mayor Bloomberg's congestion pricing proposal was ultimately blocked in the State Legislature (Schaller, 2010). Hence, in addition to all considerations discussed previously, the legislative structure is the last factor I consider in analyzing the public rejection of CP.

Schaller (2010) notes that unlike London where Mayor Livingstone had the authority to implement CP without any legislative approvals, Mayor Bloomberg and New York City needed state legislation to authorize the city to implement CP. Through this process, State Legislature identified that the NYC congestion pricing proposal would need approval by three legislative bodies, which include the City Council, both houses of the legislature, as well as the Governor. This entire legislative approval process eventually led to the Assembly Democrats blocking the vote as the deadline for federal funding neared, effectively killing
the NYC congestion pricing proposal Schaller (2010). Similarly, Edinburgh experienced complications in its bid to introduce CP due to the required legislative approvals. Rye et al. (2008) state that the Scottish Executive (i.e., the Central Government) still had considerable control over local authorities. To introduce CP, the scheme needed approval from both the Scottish Executive and the national Scottish minister. Their approval was contingent on high public support for the program. Public referendum voting then became the avenue for which the public rejected the CP proposal (Hensher and Li, 2013). Likewise, public voting in Manchester also eventually led to the rejection of the scheme (Swanson, 2009).

Probably the largest risk of rejection from the legislative structure is that it makes the introduction of congestion pricing susceptible to the political process. In New York for instance, Schaller (2010) documents the role the Assembly Democrats played in blocking the approval of Mayor Bloomberg’s congestion pricing proposal:

The key obstacle was the Democratic-controlled Assembly. Democratic Assembly members from the outer boroughs were deeply skeptical of the plan. The Assembly Speaker, although publicly supportive, left the decision on whether to bring the bill to a vote to the Democratic conference. With strong opposition from most of its New York City members, Assembly Democrats blocked a vote as the deadline for federal funding approached.

Sheldon Silver, the Assembly Speaker, represents the Lower East Side of Manhattan and was publicly supportive of congestion pricing. However, a month before the congestion pricing proposal effectively died due to inaction by the New York State Assembly, The New York Times reports that Mayor Bloomberg made a $500,000 donation to Republicans in order to help them retain control of the Senate, which angered the Assembly Democrats (Hakim and Peters, 2008, Confessore, 2008). Arguably, Mayor Bloomberg’s relationship with the Assembly Democrats might have affected their decision to not vote and effectively block the proposal. Micah Z. Kellner, a Manhattan Democrat, provides an insightful comment on this relationship documented by The New York Times: "'All politics is relationships, and if [Bloomberg] hasn’t built the relationships over time he can’t suddenly create those relationships with 48 hours to go in the process” (Cardwell and Hakim, 2008).
Sometimes, the political process and public referendum could be supportive of the introduction of congestion pricing. This was the case in Stockholm, where voters aligned with their political parties with respect to the introduction of CP (Hársman and Quigley, 2010). However, this appears to be more the exception than the rule. Though, as discussed in Chapter 4, the dynamics of the referendum could force the benefits to be distributed in objectionable ways. For instance, the permanent introduction of CP in Stockholm earmarked the revenues to a new ring-road (Börjesson et al., 2012), which could lead to further sprawl and more congestion.

3.5 Application of Proposed Framework

3.5.1 A Unified Framework

I summarize the political and institutional problems identified in this chapter through Figure 3-1. The inner box arranges the respective sources of political failures across axes of inequity (Raux and Souche, 2004) and the uncertainty (De Borger and Proost, 2012, Marcucci and Marini, 2003) of the program’s costs and benefits. The perceived distribution of benefits, costs and externalities across space and time are important considerations. Whenever there is an inequitable distribution (particularly across geographic political jurisdictions), collective action is likely to arise (Albalate and Bel, 2009, Schaller, 2010). When equity is satisfied, the uncertainty in the program’s benefits can cause further issues (e.g., credible commitment (Manville and King, 2012)). Finally, when there is an equitable distribution and certainty in the benefits and costs, free riding and loss aversion (King et al., 2007) are likely to prevail given the context of the problem.

The perceived inequity and uncertainty are then moderated by societal views. For instance, the public perception of the congestion problem must be severe enough for pricing to be warranted (Ison and Rye, 2005). Media portrayal, as in the case of Manchester (Vigar et al., 2011) also plays an important role. The public opinion about congestion pricing is also shaped by mobility related social norms, which pertain to the social pressure to accept pricing policy (Schlag and Teubel, 1997).

The public rejection that is borne out of the perceived inequity, uncertainty and negative
Figure 3-1: An inequity and uncertainty framework for analyzing political obstacles.

Societal views are then operationalized by institutional issues. The lack of a political champion affects the public's confidence in the CP proposal, which exacerbates the uncertainty about the program's benefits. Organizational challenges also cause additional complications.

Most importantly, the legislative structure becomes particularly important since this is the formal mechanism for the opposition to stop any CP proposal. In addition to its informal analog in referendum voting, which allows the public to voice out their rejection of CP, the legislative structure makes the implementation of CP susceptible to the political process, as was experienced in New York.

3.5.2 A Summary of Case Studies

The remainder of this section considers the failures of different transportation jurisdictions in introducing congestion pricing. Table 3.1 summarizes the political obstacles encountered by the failed examples of New York, Edinburgh, Manchester and Hong Kong, as examined from the framework proposed in this chapter. The rest of this section details these experiences.
Table 3.1: A summary of CP case studies viewed through the proposed framework.

<table>
<thead>
<tr>
<th>Source</th>
<th>Public Acceptance Issue</th>
<th>New York</th>
<th>Edinburgh</th>
<th>Manchester</th>
<th>Hong Kong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inequity</td>
<td>CP viewed as burden and not potential benefit</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Spatial or vertical inequity across jurisdictions</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Lack of sufficient alternatives (i.e., transit)</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Collective action from small interest groups</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Credible commitment with hypothecation</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>CP scheme or technology too complex</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Doubts about promised congestion reduction</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>Social Views</td>
<td>Congestion not perceived severe enough</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Negative press coverage or insufficient promotion</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>Institutional</td>
<td>Lack of political champion</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Risks from legislative issues and political process</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td></td>
<td>Organizational issues from multiple actors</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
</tbody>
</table>

3.5.3 New York

The New York City congestion pricing proposal was introduced in 2007, championed by Mayor Bloomberg (Schaller, 2010). NYC residents backed the proposal by a 67% to 27% margin provided that the collected fees would be used to improve transit. The proposal included a fixed $8 fee for vehicles traveling into the Manhattan core using an E-ZPass electronic tolling system. Revenues would have been devoted to transportation improvements, and the federal government promised over $300 million conditional on getting the congestion scheme approved. The scheme was understood and the promised benefits were clear. Furthermore, press coverage and public opinion about the scheme was generally positive (Schaller, 2010).

Schaller (2010) identifies the following reasons which negatively affected the outcome of Mayor Bloomberg’s bid for CP:

1. Collective action against the scheme came from the boroughs outside Manhattan (i.e., the outer boroughs), particularly Queens and Brooklyn. These areas are more auto-dependent and had the least convenient access to public transit to get to their Manhattan jobs, though it is worth noting that only 5% of these workers from these areas
commute into Manhattan by car. This exemplified an inequitable spatial distribution of benefits where some outer borough residents might not able to receive the benefits of improved public transit.

2. The situation was likely made worse by the resentment of the outer borough residents and officials towards the Manhattan-based elites. There was also some perceived intra-borough unfairness with respect to New Jersey having to pay subsidized or no tolls.

3. Those who opposed the scheme felt that mass transit was not and would not become a viable alternative to driving.

4. Many motorists felt that the promised travel time savings did not justify the $8 fee.

5. Opponents also did not trust that the revenues would be used to improve transit service, or even reach the MTA for that matter.

6. Alluding to large highway construction projects in the 1970s and 1980s, the extensive approval process required for CP to be introduced became an avenue for those opposed against the policy to block it.

Chronopoulos (2012) gives emphasis to the lack of a credible redistribution plan with respect to mass transit to address the spatial inequity: "In New York City, [mass transit improvements] did not happen because the mayor did not control mass transit and he had no plans to convince the MTA to improve public transportation." Organizational issues likely made the situation worse. In The New York Times, Jaffe (2014) reports that "[t]hree different entities manage the bridges and tunnels surrounding Manhattan–Port Authority, the Metropolitan Transportation Authority, and the city–with no concerted effort to reduce traffic."

The approval process in New York also contributed to the rejection of the congestion charging scheme. The proposed congestion pricing plan required approval from the New York State Assembly to get implemented. In contrast to the success in London, the Mayor of London had the authority to implement pricing without legislative approvals. The politics were also in favor since the automobile lobbyists were mostly aligned with the Mayors political
opponents (Schaller, 2010). While Stockholm required legislative approval, it was obtained through a fortunate set of circumstances where congestion pricing was used to reach a desired government coalition (Schaller, 2010). Inaction from the Assembly effectively killed the proposal. More importantly, as noted earlier, politics between Mayor Bloomberg and the Assembly Democrats might have also influenced the outcome (Confessore, 2008, Hakim and Peters, 2008, Cardwell and Hakim, 2008).

At present, The New York Times reports of movement in New York City to resurrect the idea of implementing congestion pricing (Jaffe, 2014). The movement calls for a "fair" tolling plan for the city calls aims to toll the bridges across New York City to better distribute traffic. Although very preliminary, the plan could generate up to $1.5 billion, a $1 billion of which is hypothecated to transit. The MTA would be managing the revenues. See Jaffe (2014) for more details.

3.5.4 Edinburgh

A two cordon scheme was proposed in Edinburgh in response to traffic congestion due to economic growth (Allen et al., 2006). ALPR technology was to be used for enforcement, and a once-a-day charge of £2 on inbound vehicles to cross either of the two cordons. The scheme was expected to raise around £760 million and be used for public transport improvements (Rye et al., 2008).

Coordination was required among three tiers of government (Allen et al., 2006). The scheme also needed the final approval of the Scottish Executive and the national Minister in Scotland, which provided support conditional on public approval (Rye et al., 2008). In 2005, a referendum was held before the charging scheme was introduced. A turnout of around 62% was achieved, with approximately 75% of the voters being against the policy. The plans were abandoned shortly after.

Rye et al. (2008) discuss the following reasons for why the Edinburgh public was opposed to the scheme, where the first three were issues raised through public consultation:

1. Congestion was not perceived to be severe enough to merit congestion charging, though a number of politicians and pro-charge lobby groups believed it to be.
2. There were also doubts that suitable public transport alternatives would have been in place prior to the introduction of the scheme, which was partly due to trust issues with the City Council.

3. Vertical equity considerations were also raised, particularly about poor drivers being priced off roads.

4. Motorists also viewed the congestion charge as another tax against them. This perception was not aided by the negative press coverage the plan received.

5. The complexity of the two cordon scheme also contributed to the public's rejection of CP (Hensher and Li, 2013).

6. Politicians outside the cordon viewed that the scheme was biased against their residents since the City of Edinburgh residents could drive without being charged.

As expected, pressure groups on both sides of the CP debate were involved. Allen et al. (2006) note that "while the strong opposition arising from the narrow economic self-interest of motorists is unsurprising, the weakness in support for the scheme from bus users who stood to gain... was unexpected." Based on interviews they conducted, Rye et al. (2008) also point out that the introduction of CP in Edinburgh lacked a political champion, unlike the case of London.

3.5.5 Manchester

In 2008, Manchester proposed a two cordon scheme similar to Edinburgh. However, £2 would be charged for crossing each cordon in the morning (afternoon) peak times for inbound (outbound) vehicles (Hensher and Li, 2013). ALPR and "tag and beacon" (i.e., DSRC) technology were chosen to enforce the charging (Ahmed, 2011). The scheme was voted down by almost 80% of the voters with a turnout of just above 50%. Had CP been successfully introduced, it would have raised over £3 billion for transport improvements across Greater Manchester (Swanson, 2009), and the revenues would have been used to improve public transportation (Ahmed, 2011).

Swanson (2009) identifies a number of reasons for the negative outcome of the referendum:
1. Congestion in Manchester was not severe enough to convince the public that pricing was needed.

2. Most people were also not aware that significant investments in public transportation were a major component of the CP proposal. Furthermore, the revenues were mostly devoted to improving bus service and generated little enthusiasm, even from the supporters of the program.

3. The public also did not perceive the current transit system to be effective and was reluctant to devote more money into it.

4. There was also distrust of the local authorities. The public did not believe that the politicians would make the appropriate investments in transit before the CP program would have been introduced.

Although the program had one overarching agency, the Transport for Greater Manchester, as the sponsor for CP (Samdahl et al., 2013), Swanson (2009) also notes that "the commitment of Manchester’s leadership to road pricing seems to have been lukewarm" from the start.

Palmer (2010) notes additional problems, including organizational issues from multiple actors, inequity and the political process:

The existence of multiple, individually represented boroughs within a single metropolitan area, similar to New York, appears to have been the ultimate downfall of the Manchester proposal. The bid to the national DfT [Department for Transport] was made by the highly factional AGMA [Association of Greater Manchester Authorities], rather than the all-encompassing Greater Manchester County Council (for instance). The disunity that existed within the AGMA as result of perceived or actual equity issues around the scheme based on respective geographic circumstances undermined the strength of the plan.

Similar to Edinburgh, the complexity of the two cordon scheme also went against the program’s public acceptance (Hensher and Li, 2013). More importantly, Vigar et al. (2011) note that the media representation did not help win support for the CP proposal. In particular, the core of the debate was framed around the charging element, and rarely focused
on the public transportation improvements that would accompany the congestion charging package.

3.5.6 Hong Kong

In 1983, Alan Scott, then Secretary of Transport, announced 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). The ERP system was piloted between 1983 to 1985, but was not implemented permanently due to public objection.

The public viewed CP as just a way to test new technology, and did not feel that pricing was necessary given the levels of congestion at that time (Ison and Rye, 2005). Ison and Rye (2005) cite Borins (1988) and Hau (1990) in noting that "there was a failure to sell the ERP scheme to the public in Hong Kong. An aggressive advertising campaign was absent and the literature available." Hence, the public saw this as inequitable to drivers (Hau, 1990), and it did not help that the media portrayed CP as an additional tax (Dawnson, 1986).

Collective action was also in play as "well-organized interest groups such as taxi drivers and commercial vehicle owners would exert political pressure to be exempt from paying the road price," which elicited further sentiments of inequity against private car drivers (Ison and Rye, 2005). In addition to voters doubting that the charges would be used to rebate other vehicle taxes, there were also great concerns that the Chinese government would not honor any commitments made by the British once they take over in 1998 (Manville and King, 2012). The process of implementation was also made more difficult due to organizational issues, particularly the role of government and the district boards (Ison and Rye, 2005).

3.6 Proposed Solutions to Political Challenges

3.6.1 Summary of Best Practices

In this section, I review the best practices learned from both successful and failed attempts at introducing congestion pricing. I present these solutions, and then discuss how they address the problems related to inequity, uncertainty, societal views and institutional issues
identified in Chapter 3. Table 3.2 identifies these best practices and the corresponding issues they mitigate.

Table 3.2: Best practices for gaining public acceptance of congestion pricing and the public acceptance issues they address.

<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Inequity</th>
<th>Uncertainty</th>
<th>Societal Views</th>
<th>Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong public education, outreach and media campaign</td>
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<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Revenue hypothecation and upfront transit investments</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Demonstration projects</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Strong leadership and clear authority</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Exemptions, subsidies and effective scheme design</td>
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</tbody>
</table>

3.6.2 Public Education, Outreach and Media Campaign

A strong communication program is key towards public acceptance, which includes educating the public on the purpose of the CP scheme (Samdahl et al., 2013). For example, Metrolinx, which is the transportation authority for the Greater Toronto-Hamilton Area (GTHA), put forward a strong media campaign to generate support for their $50 billion regional transportation plan (Metrolinx, 2008). This includes highlighting the $6 billion cost imposed by congestion on the GTHA region in 2006. Metrolinx also educated the public on the proposed revenue tools to fund the transportation plan (Metrolinx, 2013b). Multiple stakeholders, including GTHA residents, businesses and municipalities, were involved throughout the decision making process.

In addition to clearly communicating the scheme objectives, it is also important to advocate the benefits associated with congestion pricing (Samdahl et al., 2013). Having the public understand what they are receiving in exchange for the congestion charge can arguably reduce doubts about the benefits brought by CP. Recall that in Manchester, the press coverage was focused on the charging element with little attention on the transit investments that accompanied the CP package (Vigar et al., 2011). This disparity in media coverage did not help win support for the CP proposal.

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Furthermore, it is also advantageous to ensure that the scheme itself is well understood by the public (Ison and Rye, 2005). As discussed in the previous chapter, having a scheme or technology that is too complex increases the public's uncertainty about the CP program, reducing support for it. For instance, Eliasson (2008) considers the effective information campaign as one of the main reasons behind the successful congestion charging trial in Stockholm:

Apparently, people knew what to do. Anticipated problems with people who did not know that they should pay, or did not know how to pay, did not materialise. Moreover, the anticipated problem of protests in the form of large numbers of court appeals or refusals to pay was never a problem...

Based on their review of the international experience with CP, Bhatt et al. (2008) note that effective outreach and sensitivity to public acceptance are key factors for the successful implementation of CP. It is important to monitor public attitudes towards CP, as well as to reach out to stakeholders to gauge any concerns they might have with the proposed scheme. Doing so could inform other strategies that aim to minimize any resulting inequity from the implementation of CP. With respect to inequity, the likely effects of the scheme also needs to be communicated to the public, as well as the methods employed by the transportation authority to mitigate inequity issues (e.g., revenue hypothecation to transit) (Ison and Rye, 2005).

Börjesson et al. (2012) also note that the "branding" of the congestion charge may also affect its public acceptability. In Stockholm for instance, public support for CP was correlated with environmental concerns. Hence, emphasizing the positive environmental impacts of congestion charging helped its public acceptance. Finally, as mentioned earlier, the objectives of CP program needs to be clearly stated to the public (Ison and Rye, 2005), and it is useful to link these objectives with the region's goals (Mahendra et al., 2012). A public education campaign can also address any negative perceptions the public has of "paying twice" for the use of roads. Swanson and Hampton (2013) find that the public may have a perception that CP is a means of paying twice for road usage, with gas taxes as the other. (Section 4.3.1 elaborates further on congestion mitigation and revenue potentials of CP.)
3.6.3 Revenue Hypothecation and Upfront Investments

As discussed in Chapters 2 and 3, revenue hypothecation to public transport is often associated with an increase in the public acceptance of pricing (Jones, 2003). Equally important, investing the collected revenues in mass transit is an effective way to lessen some of the resulting inequities due to the imposition of congestion charges (Levinson, 2010). Viegas (2001) notes two advantages of hypothecating revenues to public transportation. First, this reduces the disutility of switching modes (i.e., it softens the blow for drivers who are priced out of the road and have to switch to transit). Second, the revenue redistribution favors low-income groups, who are often public transit patrons.

Revenue hypothecation may also be a better mechanism to address equity issues as compared to tax cuts, even though the latter may generate larger political support (Litman, 1996). In particular, public transportation investments is considered to be more progressive as opposed to tax reductions, which have a regressive effect (Eliasson and Mattsson, 2006).

However, since there is often a gap between the fare collection stage and when the revenues are used, this solution is prone to credible commitment issues (Manville and King, 2012). Hence, making upfront investments in public transportation could potentially mitigate these problems. For instance, as Rye et al. (2008) note, a public concern brought up against the introduction of CP in Edinburgh was "[w]hether sufficient alternatives to driving would have been put in place prior to the scheme's introduction, partly related to a significant lack of public trust in the Council." In contrast, the Stockholm congestion charging trial was accompanied by a pre-trial expansion in public transportation, which was marketed along with the promotion of the CP scheme (Kottenhoff and Freij, 2009).

Kottenhoff and Freij (2009) note a number of roles played by the transit expansion that helped public acceptance of road pricing throughout the Stockholm congestion charging trial:

1. Stockholm had a high initial transit mode share which contributed to the acceptance of road pricing. This is in contrast to the experience with the Edinburgh referendum, where car use was shown to influence voting behavior. In addition, the transit expansion that preceded the trial also encouraged further mode shifts from automobiles to transit.

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2. The expansion also relieved some of the anticipated crowding on existing public transportation facilities. In contrast, some of the opposition to CP in New York was due to fear that "transit riders would suffer from even more crowded trains and buses" (Schaller, 2010).

3. There was also a positive marketing effect for public transit since the new bus services were visible to and appeared to be highly appreciated by the public. This then translated to further support for the introduction of CP, as well as increased future transit revenues.

Similarly, (Swanson and Hampton, 2013) report that simple improvements to an existing public transit system should be implemented to help rebuild the public's confidence in government.

While making upfront transit investments can certainly improve the public acceptance of pricing, this may be operationally difficult for transport agencies since improving transit services (e.g., adding new buses) may require a certain lead time to procure the new fleet and train new drivers. Buses in London are privately operated, which could explain the relatively quick availability of 200 extra buses to serve the cordon area by the time CP was introduced (Banister, 2003). This lead time concern also applies to demonstration projects, which are discussed below.

3.6.4 Demonstration Projects

Demonstration projects have also been noted to improve the public acceptance of congestion pricing (Jones, 2003). In the context of the political problems identified, trial periods could decrease loss aversion or doubts about CP since it would allow some of the proclaimed but uncertain future benefits (e.g., congestion reduction) to materialize. The visible congestion reduction from the Stockholm trial was instrumental in changing the public's perception of CP (Eliasson, 2008):

The improvements in travel times and the urban environment were visible right from the start. The astonishment of seeing almost empty streets during rush hours, in particular during the first months, cannot be stressed enough. After
that, the potency of road pricing had been overwhelmingly proved, and the negative arguments shifted from 'it won't work' to other, often more constructive, arguments.

Indeed, Swanson and Hampton (2013) conclude that "[p]ilots or trials may reduce skepticism regarding the effectiveness of congestion pricing."

When a demonstration project is accompanied by a package to improve public transit (as in the case of Stockholm), problems of credible commitment can also be reduced (Manville and King, 2012). In addition to addressing credible commitment issues, Manville and King (2012) note that the Stockholm CP demonstration project "allow[ed] voters to see if prices reduce congestion, if spillover is a serious problem, and if prices have other impacts (i.e., on noise, accidents, or transit commute times)." Hence, demonstration projects can address both uncertainty about the benefits of CP as well as any negative societal views around it.

As noted by Anas and Lindsey (2011) and Albalate and Bel (2009), another benefit of a demonstration project appears to be related to its psychological impact on the public. For instance, the public perception of the Stockholm congestion trial became improved after CP was deemed to become a more permanent policy (Winslott-Hiselius et al., 2009). Schade and Baum (2007) present similar results. This suggests that public referendums should be held after demonstration projects, and not before them, unlike in Edinburgh and Manchester (Anas and Lindsey, 2011). For instance, Manchester’s bid for CP was also accompanied by upfront investments in transit, but the entire package was never approved since it was rejected by a public referendum that preceded any trial periods or public transport investments.

While holding a public referendum after upfront investments and a demonstration project can improve public acceptance, this necessitates bearing the after the fact risk that the public reject pricing in the referendum. This poses some difficulties with funding the upfront investments if they are backed by the CP revenues.

3.6.5 Strong Leadership and Clear Authority

The need for a political champion is well documented in the literature on the acceptance of congestion pricing (Ison and Rye, 2005, King et al., 2007, Rye et al., 2008, CS, 2009, Samdahl et al., 2013, Bhatt et al., 2008). As Samdahl et al. (2013) note, "[t]he newness of congestion
pricing, and typical skepticism by the public puts the onus, on a project champion to guide the project though, planning, design and implementation.” The lack of a strong political leader, such as Mayors Bloomberg and Livingstone in New York and London respectively, was one of the reasons for the public rejection of CP in Edinburgh and Manchester. In contrast, the presence of a strong champion for CP can help address some of the uncertainty the public may feel towards CP's introduction.

Institutional problems also arise due to organizational issues with respect to the multiple actors involved in the decision making process. For instance, London was able to successfully implement CP, partly due to the central government “controll[ing] the planning, design, and implementation of the congestion pricing scheme” (Samdahl et al., 2013). In contrast, the greater institutional complexity in New York, which involved State and transit agencies, served as an obstacle to CP’s successful implementation (Samdahl et al., 2013). Hence, having the presence of a single implementing agency with clear authority on introducing CP could help address some of the institutional obstacles against its introduction (Ison and Rye, 2005).

Furthermore, institutional problems are often rooted directly in the legislative structure of the region trying to implement a congestion scheme. For instance, Schaller (2010) notes that differences in the legislative approval processes can help explain why congestion pricing was adopted in London and Stockholm but failed in New York. For instance, Mayor Livingstone had the authority to implement CP whereas Mayor Bloomberg needed approval from the New York State Assembly. While there are no apparent practical solutions to this problem available (i.e., ones that do not require a legislative overhaul), it is hoped that addressing some of the sources of political failures would reduce the likelihood of opposition in the approval process. This is plausible given that political processes can be viewed as the medium in which adversely affected constituents are able to voice their concerns and block the implementation of congestion pricing programs.

3.6.6 Exemptions, Subsidies and Scheme Design

Exemptions and subsidies could also be employed to dampen the costs felt by those adversely impacted (Jones, 2003), particularly groups that incur concentrated costs and gain little
benefit (e.g., auto-dependent individuals who do not have good access to public transit). Users also need to be convinced that they will benefit from the scheme. Albalate and Bel (2009) note that "in all experiences [of CP], a large list of discounts is awarded to those citizens who are affected the most." Ison and Rye (2005) note London's experience with using exemptions and subsidies: "a discount of 90% available to residents living in the zone was activated and there is complete exemption for certain groups... A range of exemptions would appear to have smoothed the introduction of congestion charging in Central London."

Careful planning and scheme design could also alleviate some of the negative impacts felt by both drivers and residents due to the imposition of CP. For instance, upfront traffic mitigation strategies (e.g., traffic calming, which are engineering measures to slow down or reduce traffic) could appease concerns regarding rat running along residential neighborhoods as a result of the diverted traffic from the implementation of CP (Jones, 2003).
Chapter 4

Negative Impacts, Revenue Potential and Alternatives

4.1 Chapter Overview

Congestion pricing requires generating substantial support among both road and non-road users. Hence, a clear rationale must be established from the start that CP is indeed appropriate for the situation at hand. This requires understanding CP's impacts—both positive and negative—as well as other policy options available for consideration. After reviewing the observed benefits brought by CP, this chapter explores some of its negative impacts, which include: the inefficient allocation of traffic when charges are set too high; the risk of misusing CP revenues; the effect of CP on other goods and services across the transport system; the adverse impact of CP on sales; and the risk of business relocation. I then examine three alternative policies to CP, namely VMT taxes, automobile ownership regulation and parking regulation. I first introduce their revenue generating potential, which is an important consideration that is distinct from their ability to mitigate traffic. The chapter ends by presenting a small case study of how the Greater Toronto-Hamilton Area (GTHA) selected the funding tools for their $50 billion transportation plan to mitigate traffic congestion.

4.2 Negative Impacts

4.2.1 Congestion Pricing Benefits

Up until this point, this thesis has primarily focused on factors that influence the public acceptance of congestion pricing. I have implicitly assumed that road pricing is the solution
to traffic congestion, and that the main challenges associated with CP are primarily due to its public acceptance and political feasibility. However, CP is only one among a portfolio of solutions to traffic congestion. Furthermore, like any other policy, congestion pricing might also have negative impacts, some of which might have been unintended. This section explores these negative consequences. However, I begin by briefly reviewing some of the positive consequences of CP, using the recent examples of London and Stockholm.

London introduced a £5 congestion charge in 2003, which was raised to £8 in 2007 (TfL, 2007). Evans (2007) reports a benefit-cost ratio of 1.5 and 1.8 with charges at £5 and £8 respectively. According to the fifth annual impacts monitoring report (TfL, 2007), some of the benefits include:

1. A 21% reduction in the 2006 traffic entering the cordon zone compared to 2002 pre-charging values.


3. Reductions in traffic casualties and emissions in and around the charging zone.

4. Bus services have had satisfactory performance accommodating passengers.

5. Bus speeds increased in the first year of operations, but have trended towards lower speeds along with the overall Central London traffic.

It might also be possible to start examining any long-term impacts CP might have had on London’s transportation system. For instance, as will be discussed in Section 4.2.6, the introduction of congestion charging might have decreased vehicle ownership in the City of London (see Figure 4-5).

In Stockholm, congestion pricing was re-introduced permanently in 2007 after a seven-month trial held in 2006. The scheme is considered a success. Using extensive traffic measurements from April 2005 to April 2006, Eliasson (2009) report a 22% traffic reduction in the cordon area, along with other positive benefits (e.g., reductions of 2.7% and 3.6% for greenhouse gas emissions and traffic accidents). Transit fare revenues have also increased. Assuming constant yearly benefits, Eliasson (2009) estimates a benefit-cost ratio of 2.5.
In fact, Eliasson (2009) shows that both investment and operating costs are recovered in around 4 years when social benefits (e.g., travel time savings) are taken into account, net of congestion charges.

Furthermore, congestion pricing is also believed to have reduced traffic in Stockholm over the long-term (i.e., long-term cost elasticity of driving is slightly higher than short-term cost elasticity) (Börjesson et al., 2012). This means that the effects of CP did not wear off as people got used to paying a charge. Other positive effects of CP also include stimulating the demand for alternative fuel vehicles which are exempted from the congestion charge, as well as a general increase in public support for charging (Börjesson et al., 2012). Equally important, the concerns of major traffic breakdowns along the bypasses did not materialize.

4.2.2 Too Much Pricing

Now, I shift my focus to some of the negative consequences of introducing CP. I begin by looking at the possibility of worse economic outcomes when congestion charges are set too high, i.e., when the price to drive is too high, the traffic allocation may be economically inefficient. McCarthy and Tay (1993) consider Singapore such a case. Singapore introduced its Area Licensing Scheme (ALS) in 1975, and this manually enforced program was later transitioned to an Electronic Road Pricing system in 1998 (Phang and Toh, 2004). Since its inception, the ALS has been credited to reduce peak period traffic flow by 50%. However, a reduction of this magnitude might be too high, as there are also positive economic benefits associated with a certain level of congestion during peak hours. That is, a healthy level of congestion is a sign of a vibrant local economy.

Table 4.1: Length and speed characteristics of two sampled road circuits in Singapore, peak and off-peak periods. Source: Olszewski and Tan (1991).

<table>
<thead>
<tr>
<th>Road characteristics</th>
<th>Circuit A</th>
<th>Circuit B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (kilometers)</td>
<td>7.166</td>
<td>6.663</td>
</tr>
<tr>
<td>Average journey speed (km/hr)</td>
<td>27.6</td>
<td>23.3</td>
</tr>
<tr>
<td>Restricted (9:00AM-10:AM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-restricted (1:00PM-4:00PM)</td>
<td>20.3</td>
<td>16.8</td>
</tr>
</tbody>
</table>

In fact, McCarthy and Tay (1993) note that a 1990 survey carried out by the Public Works Department of Singapore found that average speeds were lower during off-peak periods than
peak periods. The data, taken from Olszewski and Tan (1991), is reproduced in Table 4.1.

Wilson (1988) also reaches the same conclusion that the high congestion charges led to a reduction in overall welfare. In addition, Wilson (1988) gives particular attention to the profitability of the ALS, which he hints as the reason for the subsequent price hikes enacted by the Singaporean government:

The ALS was quite profitable for the Singapore government... Net monthly revenue averaged about S$420,000, giving an annual rate of return on capital of 76.8% (1596.8% annual rate of return on capital expenses for ALS only). After the price increase at the beginning of 1976, the average net monthly revenue was S$518,000, giving an annual rate of return of 94.8%... Given the enormous profits possible from administration of such a scheme, it is hardly surprising that the Singapore government yielded to the temptation of raising prices in 1976 (as it has done several times since, as well).

4.2.3 Revenue Hypothecation Risks

There are also risks associated with how the congestion pricing revenues are used, particularly when this decision is made to appease the majority. For instance, unlike the Stockholm CP trial in 2006 which hypothecated CP revenues to public transit, the permanent introduction of CP in 2007 earmarked most of the revenues to a new ring-road. This was believed to improve the public acceptance of CP's permanent introduction among motorists (Börjesson et al., 2012). Rutherford (2013) notes the negative implications of this decision:

Compromise and conflict have emerged, though, in the use of the money obtained from the congestion charge... supposed to be used to finance public transport improvements... The Moderate/Alliance majority decided, however, to use the money to partly finance a new six-lane by-pass road... This decision has been subject to virulent debate at the local level between the City government, opposition parties and environmental groups... and the Greens [Party] who argue that the project is a travesty which has withdrawn a much-needed source of investment in local public transport.
While there were also accompanying rail investments which were claimed to come from other sources of financing (Börjesson et al., 2012), the diversion of revenues is arguably an example of the tyranny of the majority. That is, the interests of the majority are placed above those of individuals or other minority groups. Over the long-term, the new ring-road might also have been of interest to possible suburban beneficiaries (i.e., real estate owners). In addition to diverting money away from public transport improvements, financing a bypass using CP revenues might also induce further urban sprawl (see for instance Handy (2005) whose review of the literature shows a reasonable link between building new highways and encouraging additional sprawl). This draws a delicate tension between managing congestion and maintaining a strong and vibrant economy. That is, the CP program and consequent development of the ring-road can run against any agglomeration benefits of a dense urban economy.

There were also serious concerns of major traffic breakdowns along the toll-free Essinge bypass from drivers avoiding the cordon area, as well as increased congestion on a newly built ring-road tunnel outside the cordon (Eliasson et al., 2009). Fortunately, Börjesson et al. (2012) describe a positive result where these concerns did not materialize:

Two other fears were that the charges would lead to increased congestion problems on other links, especially the bypasses, or that the freed-up road space within the cordon would quickly be filled up with other traffic. After four years, there is no evidence of these effects. Similarly, the improvements in travel times and travel time variability remain (although in this case, there is no data after 2008).

Nevertheless, these positive outcomes do not preclude any negative impacts from how the revenues from CP could possibly be misused, such as the earmarking of revenues to finance the bypass in Stockholm.

4.2.4 Transportation Price Adjustments

The impacts from CP could also materialize in how the charges affect the supply and prices of complementary and substitute transportation goods. For instance, Jones (2003) cautions of additional parking spaces being built outside the charging zone due to the implementation
of CP. In addition to the new parking supply, parking operators (both inside and outside the cordon area), if left unregulated, might also decrease prices to attract more demand as a response to the reduction in automobile users due to CP. Levinson and Odlyzko (2008) note a study by Arup (2004) that parking revenues in Central London have dropped since the introduction of the congestion charge. This impact is confirmed by a Transport for London report (Evans, 2007): "[c]ongestion charging appears to have caused a reduction in parking activity and parking revenues in Central London but almost no change in other parts of London.” If parking operators had reduced prices to compensate for the revenue decrease, then pricing’s congestion reduction effectiveness could have been undermined.

To further explore this hypothesis, I use car rental prices in Sweden (no data on parking prices were obtained, hence car rental prices are used instead as a proxy). Figure 4-1 plots the producer price indices for car rental services in Sweden. There is a distinct drop in car rental prices after the Stockholm introduction of CP in 2007. This could possibly be due to a decrease in demand for car rentals as a result of the imposition of the charges. The price indices do recover eventually, perhaps due to adjustments in supply (i.e., some vendors exit the market).

I do caution making any direct causal links between the introduction of CP and the drop in car rental service prices. One reason to be cautious is that the data shown in Figure 4-1 is representative of Sweden as a whole and not only of Stockholm. Nevertheless, this might still be a good indicator of Stockholm conditions, given that Stockholm’s share of Sweden’s gross domestic product for the transport and storage sector has been around 25% from 2000 to 2011 (SCB, 2013). I also note that the financial crisis of 2008 is arguably a confounding factor in the data. However, it is worth noting that car rental prices drop lower relative to other transportation prices (transport and storage services and freight transport by road), as well as all other services. In any case, without the use of formal econometric tools to elicit causation (or better data for that matter), one can only draw possible links across causes and effects. Figure 4-1 is only used to illustrate a point regarding price adjustments, and studying this relationship is left for future research.
4.2.5 Retail Impacts and the Boundary Problem

Congestion pricing's impact on retail was also a major concern before CP was introduced in both London and Stockholm. Immediately after the introduction of the charges, the London Chamber of Commerce surveyed 1,430 retailers (predominantly small and medium enterprises) in the charging zone and obtained a 36.6% response rate. Based on this data, an interim report by Winsor-Cundell (2003) claims that:

1. 75% of respondents suffered a fall in year-on-year sales.
2. Just under 50% believed the CP was the primary reason for the sales fall.
3. 75% indicated that the charges had not improved their business productivity.
4. Over 25% of the respondents were considering moving outside the charging zone.
5. There was over a 10% increase in telephone orders.

Turner (2005) further supports the notion that shopping numbers have declined, and the author gives particular distinction between weekday and weekend trips into Central London.
Weekday trips are more business oriented, while weekend trips are primarily for discretionary shopping. It is the latter that has seen a large fall, probably due to people shopping elsewhere to avoid the congestion charge. However, Turner (2005) cautions that the SARS outbreak, the Iraq war and terrorism fears are confounding factors in the observed decline in sales.

In contrast, a study funded by Transport for London (TfL) find that congestion pricing did not affect overall retail sales in Central London, which is an area larger than and encompasses the congestion charging zone Quddus et al. (2007). The study, however, does find a significant decrease in sales for the John Lewis store on Oxford Street, which is a store that shared their data with the researchers. Similarly, The Guardian reports a survey of 500 businesses conducted by London First, a business lobbying firm, which shows that over 70% of companies believe that road charging is working (Clark, 2004). 32% felt that the impacts were neutral, while the rest were split 26% each for perceiving both positive and negative impacts. Equally important, "separate research by the Royal Institution of Chartered Surveyors will suggest that the charge is increasingly being used by retailers and office-based companies to demand lower rents" (Clark, 2004).

While the retail impacts in London appear mixed, Daunfeldt et al. (2011) analyze data from 20 shopping malls in Stockholm (8 within the cordon and 12 outside it), and found that congestion charges had no significant negative effect on retail. This might be because many stores in Stockholm are open on evenings and weekends, which enable consumers to avoid the congestion charges by shifting their shopping patterns (Daunfeldt et al., 2011).

It may also be useful to focus on the impacts at the boundary between charging and non-charging zones. This boundary problem is seriously considered by Rajé et al. (2004) in their study on the equity and economic issues surrounding the (failed) introduction of CP in Edinburgh. They find that "small businesses located outside the city, but servicing the city, are likely to be negatively impacted". Furthermore, they note that since the boundaries of the Edinburgh cordon are shared with other local authorities, further problems may materialize—particularly since these local authorities felt that they were inadequately consulted and would have been negatively affected by the scheme's introduction (Rajé et al., 2004).

Rajé et al. (2004) cite various news reports that indicate the following possible negative impacts of CP:

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1. Businesses inside the cordon were concerned that shoppers would drive to Glasgow instead of Edinburgh.

2. Healthcare resources would have to have been diverted to cover the congestion charges for their staff.

3. Police were considering relocating their headquarters to avoid the charge.

While CP failed to get public acceptance in Edinburgh for a variety of other reasons (as discussed in Chapters 2 and 3), it is clear that the negative impacts of CP was on the mind of the public during the congestion pricing debate.

4.2.6 Land Use Effects and Relocation Risks

A final set of potential problems I consider is rooted in the consequent land use impacts of CP. For instance, does CP induce firms to relocate closer to the core or relocate away from the charging zone? The literature seems to be still unclear at this point. Löchl (2006) conducts a thorough review of road pricing and land use studies and concludes that "neither theory nor applied research seems to provide a general answer to the question, if such pricing schemes in inner city areas will result in more compact or disperse development in view of residential and employment land uses".

Most theoretical models do suggest a centralizing effect for residential land use, but have mixed predictions on the spatial impacts on firms (Löchl, 2006). For instance, a computable general equilibrium model by Anas and Xu (1999) show that CP would induce firms located at the core to disperse away, relocating closer to their workers and customers due to the higher wages and rents brought about by CP. They predict a centralizing effect for residents who want to minimize commuting costs, and also find that this dominates the decentralizing effects on firms. A model proposed by Zhang and Kockelman (2014) similarly shows that CP induces a more dense urban form, with some associated job decentralization. These, along with recent work of Brinkman (2013), suggest that CP can potentially damage agglomeration benefits.

Löchl (2006) notes the lack of empirical data on the land use effects of congestion pricing, particularly due to the long time required for impacts to materialize. He cites studies by
Transport for London that conclude neutral impacts of CP in London. According to the fifth annual impacts monitoring report (TfL, 2007):

Analysis of comparative trends in various indicators of business performance, including change in jobs, business populations and turnover, continued to show no evidence of differential effects between the charging zone and comparator locations that might be indicative of a congestion charging effect—either positive or negative—on aggregate business performance in central London with the £5 charge... Analysis of latest data continues to show no evidence of differential effects between the central London charging zone and comparator locations that might be indicative of a congestion charging effect.

Despite the TfL findings of the relatively neutral impact of CP, the retailer survey by the London Chambers of Commerce find that just over 25% of retailers were considering relocating their stores to an area outside the charging zone (the fraction considering relocation rises to almost 40% for food stores) (Winsor-Cundell, 2003). In addition to a possible decrease in foot traffic, there was concern that supplier costs would increase due to the introduction of CP.

To take a closer look into the retail relocation risks due to CP, I conduct an empirical analysis using data on London jobs and office/retail units. While no clear linkages between CP and land use impacts can be concluded, the analysis indicates that the risk of businesses relocating away from the core should not be discounted. In conducting my study, I aggregated the London boroughs into five geographic groups:

1. City of London - main area affected by London congestion charge.

2. Partial boroughs - boroughs partially affected by the congestion charge (Camden, Islington, Lambeth, Southwark and Westminster).

3. Adjacent boroughs - boroughs adjacent to areas affected by the congestion charge (Hackney and Towers Hamlet).

4. Inner London (Camden, Greenwich, Hackney, Hammersmith and Fulham, Islington, Kensington and Chelsea, Lambeth, Lewisham, Southwark, Tower Hamlets, Wandsworth...
Figure 4-2: Jobs index in London by area (2003 = 100). Source: ONS (2013).

and Westminster).

5. Outer London - all other boroughs not part of Inner London.

The figures below summarize the analysis. The baseline year is 2003, which is when CP was introduced in London. I only show data until 2006, to try and remove any effects of the Western Extension, which was introduced in 2007 and removed in 2011 (TfL, 2008). The trends for inner and outer London are intended to serve as a benchmark for how the three other aggregations perform over this period.

Figure 4-2 plots the changes in the number of jobs for the five aggregations from 2000 to 2006. From 2003, it appears that most of the relative job growth occurred in areas adjacent to the CP zone, while the City of London experienced a relatively small decline in jobs. Partial boroughs did not deviate from the trends observed for inner and outer London.

Figure 4-4 illustrates the changes in office units, which also shows more growth for areas in adjacent boroughs. Note that the 2003 levels for the City of London seems to have declined from their 2000 levels, but their growth post-2003 appears to have followed the overall London pattern. Figure 4-4 displays the opposite trend for retail units. The figure depicts a continuous growth of retail units in the City of London beginning in 2000, and
going up until 2006. The adjacent and partial boroughs did not seem to deviate from the overall London trend.

Again, I would caution forming any cause and effect relationships between CP and the changes in jobs and retail/office units. For one, these trends could simply be explained by the dynamics of the region with respect to where the latest areas of development were happening. For instance, the growth in office units and jobs for the adjacent boroughs (Figure 4-4) may simply be because the City of London and areas included in the partial boroughs aggregation are already well developed. Hence, most of the development and growth occurred in non-core locations (the adjacent boroughs). Nevertheless, what the figures do show is that the risk of offices and retailers relocating outside the core (and charging zone) should be properly considered when thinking about introducing CP.

Despite all the plausible negative impacts of CP in London, there are arguably positive consequences as well. For instance, Figure 4-5 shows a strong decline in the number of licensed vehicles for the City of London. While this trend started prior to 2003, and may have also been influenced by other transportation policies, the decline in vehicle ownership can be interpreted as a move away from car use towards transit—perhaps due to a carrot and
Figure 4-4: Retail units index in London by area (2003 = 100). Source: VOA (2012).

stick approach of congestion charging while improving bus services through CP revenues.

### 4.3 Alternatives to Congestion Pricing

#### 4.3.1 Congestion Pricing and Transport Finance

This thesis, so far, has also viewed congestion pricing as a standalone policy to mitigate traffic congestion. However, CP is only one solution among a suite of tools available to transport authorities. This section considers how CP fits within this portfolio of options. In particular, I examine another pricing variant, namely taxes on vehicle miles traveled (VMT), as well as the regulation of automobiles and parking spaces. While this is in no way a comprehensive treatment of the existing solutions to congestion, it is hoped that the comparisons here drawn are illustrative of the trade-offs often made when choosing among options to mitigate congestion.

To motivate this discussion, I briefly review CP's relationship with transport finance, which is an important dimension of any transportation policy. User fees, which are charges incurred by users to access transport facilities, have been the major source of financing for
the U.S. transportation system (TRB, 2006). Most of the collected revenues are spent on highways (79% of the $107 billion collected in 2004) and some on public transit (10% of 2004 revenues) (TRB, 2006). Since 1919, motor fuel taxes have been the primary source of funding (Balducci et al., 2011). In 2004 for example, fuel taxes made up the lion’s share of user fee revenues (64%), with the rest comprised of vehicle registration fees, excise taxes on truck sales and tolls TRB (2006).

At present, the U.S. transportation system faces a financing challenge (Wachs, 2006). Fuel taxes have risen slower than either traffic volumes or transportation system costs: they can no longer cover the construction, operations and maintenance costs required by transport facilities. Since fuel taxes are excise taxes (i.e., levied by the gallon), inflation, high gas prices, improved automobile efficiencies and new environmental regulations have eroded their effective revenue potential (Wachs, 2006, TRB, 2006). A simple solution might be to increase the rate per gallon as the inflation adjusted cost per mile. However, there has been political unwillingness to raise the gasoline taxes to keep pace with inflation and fuel economy. Consider that fuel taxes have only been raised a few times since the 1980s (Wachs, 2006).

Figure 4-5: Number of vehicles index in London by area (2003 = 100). Source: DfT (2013).
As a revenue source, congestion pricing is similar to tolls, although there is a often a distinction made between these terminologies. CP, as discussed in this thesis, primarily attempts to manage travel demand and mitigate traffic congestion. On the other hand, tolling’s main purpose is to finance the construction and maintenance of transportation facilities (Li and Hensher, 2012). Furthermore, the CP examples used in this thesis have been limited to cordon-based programs, while tolling is often associated with a specific transport facility (e.g., roads, bridges and tunnels). However, I have also referred to examples when these distinctions are blurred (e.g., Stockholm financing a new ring-road through CP revenues).

In response to the funding risks associated with fuel taxes, the National Cooperative Highway Research Program conducted a study on alternative revenue sources, which include cordon pricing, tolling and VMT taxes (Balducci et al., 2011). Present estimates still put the current fuel taxes as the most cost-effective revenue system, with a 1% share of cost to revenue and approximately a $1.2 per vehicle operating cost (Balducci et al., 2011). Based on limited data, the share of cost to revenue for a VMT system is estimated to be around 7%, but with a much higher operating cost ($75 per vehicle).

In comparison, the cost to run a tolling system is estimated to consume around 33.5% of revenues. CP programs are of similar magnitude; Table 4.2 displays approximate revenues and costs for operational systems discussed in this thesis. When it is considered how few CP programs have been successfully implemented, it seems appropriate to view CP as a tool to reduce congestion, with the revenues used to address inequity issues and support alternate modes (e.g., transit). That is, CP seems more appropriate for congestion management and not as a revenue raiser.

Table 4.2: Approximate costs and revenues for operational congestion pricing cordon systems (2005 values). Source: Balducci et al. (2011). *Includes capital costs.

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Stockholm</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating cost</td>
<td>€133 m/y</td>
<td>€40 m/y</td>
<td>€7 m/y</td>
</tr>
<tr>
<td>Average charge</td>
<td>€7.4/day</td>
<td>€2.7/day</td>
<td>€0-2/trip</td>
</tr>
<tr>
<td>Fee income</td>
<td>€275 m/y</td>
<td>€80 m/y</td>
<td>€39 m/y</td>
</tr>
<tr>
<td>Operating cost as % of revenue</td>
<td>48%</td>
<td>25%</td>
<td>7%</td>
</tr>
<tr>
<td>Annualized cost as % of revenue*</td>
<td>55%</td>
<td>40%</td>
<td>40%</td>
</tr>
</tbody>
</table>
In the following sections, I take a deeper look into VMT taxes as well as the regulation of automobiles and parking spaces. I focus on their potential to mitigate traffic congestion, comparing and contrasting them to congestion pricing. The objective here is to better locate where CP sits among these options. Afterwards, Section 4.4 presents a case study on Toronto's $50 billion transportation plan to address congestion that uses some of the options discussed.

4.3.2 VMT Taxes

VMT taxes, a mileage-based user fee system, has received considerable attention in recent years, and is supported by some U.S. policymakers as a means to finance transportation (Whitty and Svadlenak, 2009). A VMT system could be implemented in a variety of ways, including: adopting it to a limited area or across an entire transportation system; collecting charges based on simple odometer readings or more precise methods; as well as charging flat fees or fees that vary by time of day, direction of travel, type of vehicle, etc. (Balducci et al., 2011). A number of issues remain before a VMT system could be fully implemented, even at a state level. Designing minimum system requirements (e.g., metering the distance traveled, applying the charges, billing the customer, etc.), selecting enabling technologies, and structuring appropriate rates are some of these issues (Whitty and Svadlenak, 2009). Equally important, inequity considerations arise once more, although this could be partly addressed by exemptions similar to CP (King, 2009).

A VMT system could also be viewed as a means to reduce traffic congestion, just like congestion charging. In fact, both VMT taxes and CP are premised on the idea of marginal cost pricing (though, as a matter of technicality, I note that neither VMT taxes nor CP are true marginal cost pricing systems unless the charges are differentiated by time of day, emissions, etc. in order to fully internalize the societal costs imposed by a single user). Nevertheless, a properly designed VMT system can enable the transportation operator to impose highly differentiated prices that reflect the externalities generated by individual vehicles (Balducci et al., 2011). However, it is important to distinguish CP from VMT. The former is often used to mitigate congestion, while the latter is being explored as an alternative financing mechanism.
While a CP component could theoretically be added to a VMT system, a conflict arises when a VMT system is adopted to employ differentiated pricing with the goal of managing congestion (Balducci et al., 2011):

When setting prices for congestion, there is a trade-off between the ability to manage congestion efficiently and the ability of the driver to make decisions based on the efficient price. Prices set in advance may not accurately reflect conditions at any given time, but prices that vary dynamically may not allow the driver sufficient advance information to change behavior.

In line with this, Bonsall et al. (2007) review evidence from congestion pricing schemes for roads, other transport modes and other industries (e.g., telecommunications). Using relevant models of human decision making, they conclude that people might encounter difficulties in responding effectively to complex price structures. Furthermore, people’s limited capabilities to estimate distances as well as their attitudes towards the fairness of the charge affect their response to highly differentiated pricing. In short, while it may be economically efficient to adopt a VMT or CP system that fully differentiates prices, there is a risk that these charges may be excessively varied. This could lead to information overload and confusion among the public, undermining CP’s objective to influence travel behavior.

The revenue generation and congestion mitigation objectives of a VMT system could also be in conflict with each other. For example, setting efficient congestion charges may not generate the appropriate amount of revenue (Balducci et al., 2011). That is, the optimal charge that covers transportation system costs may not be equivalent to the optimal Pigouvian tax that reduces congestion (Mahendra et al., 2012). In fact, "if the objective is to maximize net revenues rather than manage congestion, taxes on fuels and vehicles are much cheaper to collect" (JTRC, 2010). Congestion management charges would also generate little or no revenues on low-volume roads (Balducci et al., 2011).

4.3.3 Automobile Ownership Regulation

In the United States, vehicle registration fees are another source of revenues for all three levels of government to fund transportation infrastructure. In 2004 for instance, vehicle
registration and operator license fees made up 28% of total highway user revenues, and accounted for 9%, 38% and 25% of federal, state and local government revenues respectively (TRB, 2006). Along with serving as a source of revenue, a related use of charging for vehicle registration is to employ it as an alternative to CP or VMT taxes. That is, registration fees could be used to dampen automobile ownership, or even by employing a car quota system in urban areas. While this point is moot in the United States given existing automobile ownership levels, it is still a useful exercise to briefly review international experience with this policy in order to draw lessons regarding its effectiveness and public acceptance.

Singapore is the world’s premier example in using car quotas to manage travel demand. In addition to the Area Licensing Scheme, Singapore introduced the Certificate of Entitlement (COE) in 1990, which is a vehicle quota system to control automobile growth in the country (Koh and Lee, 1994). Under this quota system, an owner of a new vehicle needs to obtain a COE, which is a quota license that can be won through an open bid uniform price auction conducted monthly. The car quota appeared successful, as it "achieved the planners' intention of achieving absolute certainty in the numbers of cars... also had the intended effect of improving the quality of cars imported into Singapore" (Phang et al., 1996).

The success of Singapore's vehicle quota system led transport authorities in Shanghai and Beijing to adopt this policy (Wang, 2010). In 2004, both Shanghai and Beijing had about 2 million vehicles each. However, by 2010, vehicle ownership grew to over 3.1 million and 4.8 million in Shanghai and Beijing respectively (Chen and Zhao, 2013a). One reason for the slower car ownership growth in Shanghai is that it had started its quota system in 1994, while Beijing only adopted a vehicle quota in 2011 (Chen and Zhao, 2013a). Another distinction between the two cities is that Shanghai decided to use a bid price system similar to Singapore, whereas Beijing adopted a car lottery approach. While both may dampen car ownership, the former is advantageous since it generates revenues that could be hypothecated to transit or other transportation initiatives, similar to CP.

Alluding to earlier discussions on the public acceptance of congestion pricing, tensions between economics and equity again resurface when considering the design of a vehicle quota system. On one hand, a bid price approach is more efficient and could serve as a significant source of revenues (e.g., up to $800 million USD for Shanghai) which could be earmarked to.
transit projects, whereas a lottery system is perceived fairer since every local resident has equal chance of obtaining a vehicle (Zhao and Block-Schachter, 2013). Furthermore, a bid price design not only can bring about inequity and affordability concerns, but this could also lead to some speculative activities (Chen and Zhao, 2013a), as was initially experienced in Singapore (Koh and Lee, 1994).

However, a car lottery distorts the vehicle allocation process since entry into the quota system is not linked to a person’s need to travel (Zhao and Block-Schachter, 2013). There are also two main equity issues related to: 1) barriers to license ownership for non-resident migrants; and 2) grandfathering of all vehicle licenses issued prior to the introduction of the quota in 2012. Zhao and Block-Schachter (2013) find more support for Beijing’s lottery system. Chen and Zhao (2013a) point out that the revenues from Shanghai’s license auction system are likely responsible for the rapid transit growth in this city. However, revenue usage has not been made transparent to the public (Chen and Zhao, 2013a), which could explain the lower support for it. Furthermore, since Shanghai’s auction system gives car owners lifelong entitlement to a license (Chen, 2011), the policy might not be a stable revenue source and could even lead to speculative behavior.

It is also interesting to note how public acceptance of Shanghai’s system has developed over the years. Chen and Zhao (2013b) find that car owners (who have paid the high license fees) become supporters of the car quota policy, contradicting the commonly held notion that car owners are generally against vehicle reduction policies. Their acceptance also appears to increase over time, and in fact, "[a]s the percentage of local car owners grows, the auction policy gains more support and becomes almost irreversible" (Chen and Zhao, 2013b). Guangzhou is hoping to balance the economics versus efficiency trade-off as well as improve public acceptance by using a hybrid model that combines both auction and lottery designs (Chen and Zhao, 2013a).

The public acceptance of a transportation policy is an important consideration in itself, and not only because it is needed to get the policy introduced. Continued acceptance is also important to maintain or refine policies in the future. Even in countries with very strong governments, public acceptance is still a significant concern. For instance, in the early 1990s, Toh (1994) considers the high cost of automobile ownership and usage in Singapore
a significant risk to the country's future. Toh (1994) views the unhappiness the young generation bears with respect to Singapore's strict transportation policies a pressing concern. He alludes to the problem of "graduates with medical, engineering, science, and business degrees have migrated to Canada, Australia, and other British Commonwealth countries", which is a serious risk for a nation that "relies and thrives on the wits of its people" (Toh, 1994).

Singapore also presents a unique example where both automobile regulation and congestion pricing have been implemented. Citing previous research, Phang and Toh (2004) note that the income elasticity of demand for car ownership was 1.0, but the price elasticity of demand was very high. This implies that placing premiums on automobile prices would not significantly reduce their purchase, but a congestion charge could seriously decrease driving. Perhaps this is because the automobile has become the "ultimate status symbol" for Singaporeans, since the population predominantly lives in homogeneous, high-rise, high-density housing (Toh, 1994). In addition, the high cost of the automobile—an artifact of automobile regulation—may also explain the "status symbol" placed on car ownership.

4.3.4 Parking Regulation

A final policy option I consider is influencing travel behavior through parking controls, either by regulating the price or the supply of parking spaces. This is a promising option given evidence of high-sensitivity of drivers to parking prices (Hensher and King, 2001, Miller, 1993). Furthermore, there is also evidence that providing workers the cash equivalent of subsidized parking costs can reduce solo automobile commuting (Shoup, 1997). For a deeper look into parking regulation, Marsden (2006) reviews the impacts of parking policies, while Button (2006) chronicles the institutional structures that have shaped today's parking policies. In addition, Litman (2013) gives a detailed account on parking taxes and their impacts.

Parking regulation's relationship with congestion pricing has received some attention in the literature. Verhoef et al. (1995) consider parking regulation a less efficient policy tool compared to CP:

Using parking levies instead of road pricing for charging road users for [their]
external cost necessarily means that each individual road user will be charged some weighted average of the individual marginal external costs generated rather than his or her actual individual value... [A]t the parking place, the regulator is simply not able to differentiate regulatory fees according to individual trip lengths... Here, a policy which allows for differentiation according to trip lengths (fuel taxes, for instance) offers a superior alternative... Likewise, because parking levies cannot be differentiated according to specific routes followed, they can never be a perfect substitute for road pricing when external costs differ between possible routes.

I do note that pricing parking spaces as a congestion management tool is similar to cordon-pricing programs, except that through trips are not captured. While the inability to affect through trips is certainly a valid issue, it may not make much of a difference compared to cordon-based schemes since the cordon areas themselves are often the destination for most incoming drivers, (e.g., Manhattan).

Using a simple economic model, Verhoef et al. (1995) also find that regulatory parking fees are more efficient than physical restrictions on parking spaces. However, I note that allocations made based on willingness to pay (when spaces are priced) can also run into fairness considerations compared to allocations on a first-come-first-served basis (when spaces are restricted). A similar analogy can be drawn for congestion pricing and no-drive zones.

In terms of eliciting a behavioral response from the public, a stated preference survey of university workers from Israel showed a higher demand elasticity to congestion charges than parking fees (-1.8 vs. -1.2 respectively) (Albert and Mahalel, 2006).

Nevertheless, what is important to note is that parking policies may be a more politically viable option than CP. Verhoef et al. (1995) make reference to the public rejection of road pricing in Hong Kong, and how that influenced many transportation authorities to focus on other congestion mitigation options, such as parking regulation. For example, aggressively pursuing stringent parking regulations instead of CP might have been a better option for New York City. This is because on-street parking rates and parking zoning are under the control of the NYC Department of Transportation, whose commissioner is appointed by the mayor. In fact, a report by Weinberger et al. (2008) found that current parking regulations in
New York City encouraged car ownership and use, contradicting other congestion mitigation policies employed by NYC. Other works support the link between parking regulation and automobile ownership. In London, parking standards have been found to affect residential parking supply (Guo and Ren, 2013), and in New York City, residential parking supply has then been shown to influence household car ownership (Guo, 2013).

I do note that Mayor Bloomberg’s final proposal to introduce CP into NYC did include plans to: 1) increase on-street parking rates within the cordon; and 2) eliminate residential tax deductions for off-street parking in parking garages and lots within the CP zone (Schaller, 2010). A series of focus groups with New Yorkers shows both the public’s aversion to higher fees and concern regarding equity issues of this scheme. "Some respondents thought that the higher fees would be unfair to working people shopping for school supplies and doing other necessary errands... higher parking fees would attract wealthy drivers while unfairly penalizing less wealthy shoppers" (Schaller, 2006).

While many transportation departments do not have the authority to impose off-street parking charges (Bonsall and Young, 2010), it is an option for some jurisdictions such as New York City, which imposes a tax of 18.5% and 10.5% on commercial and residential parking in Manhattan (Litman, 2013). Litman (2013) distinguishes between commercial parking taxes and per-space parking levies. The former are taxes on parking rental transactions, which discourages owners from pricing their parking supply. The latter distributes the taxes more broadly, and can incentivize property owners to manage their parking supply and prices more efficiently. This also encourages owners to reduce parking supply, but it is challenging to implement since it requires a parking space inventory for a region. In both cases, Litman (2013) notes that parking levies "provide double dividends by raising revenues and helping to achieve other planning objectives such as reducing traffic congestion, air pollution and sprawl."

4.3.5 Tools Summary

Table 4.3 summarizes a small subset of existing programs that employ congestion pricing, vehicle quota and parking levies throughout the world. (No solid data on VMT systems were obtained, but there have been some trials of this technology in the U.S. and in Europe (Bal-
ducci et al., 2011). The table illustrates the revenue generation and congestion mitigation potentials of these tools. However, caution must be taken in comparing these options since the revenues and congestion impacts are context dependent. For instance, the revenues and traffic reduction would depend on the size of the automobile user base and initial congestion levels. More importantly, the table does not reference any of the institutional and political constraints that might pose to be the most significant factor in choosing a policy option (e.g., New York City can regulate on-street parking but would need legislative approval to implement CP). Nevertheless, the table provides some intuition on what could be accomplished using these options.

Table 4.3: Revenue generation and congestion mitigation potentials of select policy tools. Sources: Bhatt et al. (2008), Chen and Zhao (2013a), Koh (2004), Yang et al. (2014), Hamer et al. (2009), Litman (2013).

<table>
<thead>
<tr>
<th>Program</th>
<th>Location</th>
<th>Revenues (USD)</th>
<th>Congestion Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>30-35 km/h to 40-45 km/h (2004)</td>
</tr>
<tr>
<td>Cordon charging</td>
<td>Stockholm</td>
<td>$100 M (2006)</td>
<td>10% to 15% traffic decline (2006)</td>
</tr>
<tr>
<td>Cordon charging</td>
<td>Singapore</td>
<td>$100 M (2005)</td>
<td>24% traffic reduction (post-1998)</td>
</tr>
<tr>
<td>License auction</td>
<td>Shanghai</td>
<td>$800 M</td>
<td></td>
</tr>
<tr>
<td>License auction</td>
<td>Singapore</td>
<td>$75 M (average)</td>
<td>4.4% vehicle growth (1975-1989)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.9% vehicle growth (1990-2001)</td>
</tr>
<tr>
<td>License quota</td>
<td>Beijing</td>
<td></td>
<td>75% less new car registration (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15% to 8% decline of growth (2012)</td>
</tr>
</tbody>
</table>

4.4 Toronto Case Study

4.4.1 Overview

This section presents a small case study of how the Greater Toronto-Hamilton Area (GTHA) selected the funding tools for their $50 billion transportation plan to mitigate traffic congestion. This case study aims to illustrate:

1. Combining different policy tools, some of which are discussed in the previous sections, as part of a portfolio of solutions.
2. Examples of the best practices in getting a transportation plan implemented and accepted by the public, including strong public education and involvement, demonstration projects and revenue hypothecation.

3. The trade-offs when selecting policies, particularly between shifting the burden of cost among different stakeholders and obtaining their support.

Note that the monetary values throughout this section are in Canadian dollars.

4.4.2 Congestion in the GTHA

The GTHA is Canada's largest urban region and the fifth largest in North America (Metrolinx, 2013c). It is the country's economic heartland and busiest transportation gateway. The GTHA's population is also projected to increase from 6.6 million today to 9 million in 25 years. However, compared to other major urban regions around the world, the GTHA has significantly underinvested in transit infrastructure over the past two decades (Metrolinx, 2013b). The lack of investments has led to significant traffic congestion, which costs the region almost $6 billion per year: $3 billion in added costs for commuters and $2.7 billion in lost opportunities to the economy (HDR, 2008). At just under 1.5 hours per round trip, the average GTHA commute is also one of the worst in North America (Metrolinx, 2013c). This economic burden, along with the environmental and health impacts from road emissions, makes a strong case for significant transit investment (Metrolinx, 2013b).

In 2008, the GTHA's transportation authority, Metrolinx, put forth the Regional Transportation Plan ("The Big Move") to address the challenges posed by congestion (Metrolinx, 2013b). The Big Move is a 25-year, $50-billion plan for an integrated transit and transportation system for the region (Metrolinx, 2008). With a vision of enhancing the quality of life and improving the economic competitiveness of the GTHA, The Big Move is the region's largest transit expansion in half a century (Metrolinx, 2013c). As of early 2013, over $16 billion of transportation projects have already been funded through contributions from the federal, provincial and municipal governments (Metrolinx, 2013c). Current projects are underway, including subway expansions, new light rail and bus rapid transit services, an airport-downtown rail link and subway station revitalizations (Metrolinx, 2013a).
However, $34 billion is still needed to fund the remaining projects, which is about $2 billion per year. On June 1, 2013, Metrolinx was mandated to provide the Ontario Government and local municipalities an investment strategy, which includes the proposed suite of revenue tools to support the continued implementation of The Big Move (Metrolinx, 2008).

4.4.3 A Portfolio of Solutions

A report commissioned by Metrolinx evaluated 25 revenue tools that could support the continuation of The Big Move (AECOM, 2013). Table 4.4 displays a subset of these tools under consideration, along with brief descriptions of how each of them work. Note that I selected this subset by focusing on tools that appeared promising or received some support from various stakeholders (discussed in the next section).

Metrolinx considers three distinct groups of who pays for the transportation investments, based on who uses or benefits from it (Metrolinx, 2013a):

1. User pays - recognizes the value to direct users of the infrastructure.

2. Beneficiary pays - recognizes the economic value generated by the infrastructure.

3. Everyone pays - recognizes the broad social value of the infrastructure.

For example, motorists use roads and highways, so fuel taxes are considered user fees. Owners of commercial parking spots benefit from transportation investments. Hence, parking levies charge the beneficiaries. A sales tax is an example of an "everyone pays" tool. I do note that there is often some overlap between these groups with respect to the benefits they receive. Antos (2007) finds that the transit subsidy in Chicago disproportionately benefits automobile users who receive more congestion benefits than what they have paid.

Table 4.5 provides the projected revenues for each tool above, their main assumptions, as well as who shoulders the cost. The numbers are mostly based from a study by AECOM and KPMG (AECOM, 2013) supplemented by other estimates. These values also agree with and have been accepted by the Toronto Region Board of Trade (TRBT, 2013), the City of Toronto (CoT, 2013), and the model assumptions used (e.g., fuel tax of $0.10/liter) fall within acceptable ranges according to public surveys (FC, 2013, MASS LBP, 2013).
Table 4.4: Subset of revenue tools considered by Metrolinx. Source: Metrolinx (2013b), AECOM (2013).

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordon Pricing</td>
<td>Motorists are charged a toll for entering the downtown core.</td>
</tr>
<tr>
<td>Developmental Charges</td>
<td>One-time levies imposed on new developments and eligible re-developments.</td>
</tr>
<tr>
<td>Fuel Tax</td>
<td>Motorists pay a tax based on the volume of fuel purchased.</td>
</tr>
<tr>
<td>High Occupancy Tolls</td>
<td>Charges are applied to those who want to use high occupancy vehicle lanes.</td>
</tr>
<tr>
<td>Highway Tolls</td>
<td>Motorists pay a distance-based toll on designated highways.</td>
</tr>
<tr>
<td>Land Value Capture</td>
<td>Applied to collect a share of the increased property value from transport investments.</td>
</tr>
<tr>
<td>Parking Levy</td>
<td>Property owners are charged based on the amount of non-residential, off-street parking spaces owned.</td>
</tr>
<tr>
<td>Payroll Tax</td>
<td>Employers pay a tax based on their employee's gross pay or the number of employees they have.</td>
</tr>
<tr>
<td>Property Tax</td>
<td>Property owners pay a tax based on their property values.</td>
</tr>
<tr>
<td>Sales Tax</td>
<td>A sales tax is applied on all goods and services.</td>
</tr>
<tr>
<td>Transit Fare Increase</td>
<td>A fare surcharge dedicated to capital projects.</td>
</tr>
<tr>
<td>Vehicle Kilometers</td>
<td>Motorists pay a distance-based toll traveled within a designated area.</td>
</tr>
<tr>
<td>Traveled (VKT) Fee</td>
<td></td>
</tr>
<tr>
<td>Vehicle Registration Fee</td>
<td>Vehicle owners are charged for registering a new vehicle or renewing registrations.</td>
</tr>
</tbody>
</table>
Table 4.5: Projected revenues (in 2014 dollars) and assumptions of the tools in Table 4.4.  

<table>
<thead>
<tr>
<th>Tool</th>
<th>Who Pays?</th>
<th>Assumed Rate</th>
<th>Revenues (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordon Pricing</td>
<td>Users</td>
<td>$8/vehicle/entry</td>
<td>$110 M</td>
</tr>
<tr>
<td>Developmental Charges</td>
<td>Beneficiaries</td>
<td>15% increase</td>
<td>$100 M</td>
</tr>
<tr>
<td>Fuel Tax</td>
<td>Users</td>
<td>$0.10/liter</td>
<td>$660 M</td>
</tr>
<tr>
<td>High Occupancy Tolls</td>
<td>Users</td>
<td>$0.30/kilometer</td>
<td>$25 M</td>
</tr>
<tr>
<td>Highway Tolls</td>
<td>Users</td>
<td>$0.10/kilometer</td>
<td>$1,400 M</td>
</tr>
<tr>
<td>Land Value Capture</td>
<td>Beneficiaries</td>
<td>To be determined</td>
<td>$20 M</td>
</tr>
<tr>
<td>Parking Levy</td>
<td>Beneficiaries</td>
<td>$1/space/day</td>
<td>$1,400 M</td>
</tr>
<tr>
<td>Payroll Tax</td>
<td>Beneficiaries</td>
<td>0.5%</td>
<td>$700 M</td>
</tr>
<tr>
<td>Property Tax</td>
<td>Beneficiaries</td>
<td>5% overall</td>
<td>$670 M</td>
</tr>
<tr>
<td>Sales Tax</td>
<td>Everyone</td>
<td>1%</td>
<td>$1,400 M</td>
</tr>
<tr>
<td>Transit Fare Increase</td>
<td>Users</td>
<td>$0.15/ride</td>
<td>$50 M</td>
</tr>
<tr>
<td>VKT Fee</td>
<td>Users</td>
<td>$0.10/kilometer</td>
<td>$1,600 M</td>
</tr>
<tr>
<td>Vehicle Registration Fee</td>
<td>Users</td>
<td>$100/registration or renewal</td>
<td>$300 M</td>
</tr>
</tbody>
</table>

4.4.4 Evaluating Public Acceptance

Throughout the development of The Big Move, Metrolinx has placed significant effort in educating the public and getting them involved in the process. For example, Metrolinx provided a number of resources such as a primer on the GTHA’s transportation issues and funding (Metrolinx, 2013c) and a fact sheet on the revenue tools under consideration (Metrolinx, 2013b). Metrolinx also conducted public roundtable meetings to assess the public’s acceptance of the revenue tools under consideration (MASS LBP, 2013). Most importantly, Metrolinx explained the rationale for The Big Move, which is to invest heavily into transit projects across the GTHA, which have historically gone underfunded.

In selecting the final set of revenue tools to fund The Big Move, Metrolinx consulted with a number of stakeholders. These stakeholders include:

1. business advocates, like the Toronto Region Board of Trade (TRBT, 2013);

2. local municipalities, such as the City of Toronto, (CoT, 2013);

3. the residents of the GTHA through public roundtable meetings held by Metrolinx (MASS LBP, 2013), as well as the Toronto Talks Transportation public consultation series (FC, 2013).

<table>
<thead>
<tr>
<th>Tool</th>
<th>City of Toronto</th>
<th>Toronto Region Board of Trade</th>
<th>Public Roundtable</th>
<th>Toronto Talks Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordon Pricing</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Developmental Charges</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Tax</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>High Occupancy Tolls</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway Tolls</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Value Capture</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Parking Levy</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payroll Tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property Tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales Tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit Fare Increase</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VKT Fee</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Registration Fee</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.6 presents the policy options considered and which stakeholders support each policy tool. The first two stakeholders represent important views from the political and business communities, while the last two columns show the views held by the general public. Note that the distribution of the costs of paying for The Big Move (i.e., who among the stakeholders shoulder the cost burden) is determined by the final suite of revenue tools chosen. Note that for the Toronto Talks Transportation consultation, the tools with checkmarks correspond to the top 6 out of 14 options voted on by the participants of the consultation process.

4.4.5 Selected Tools

Different stakeholders have varying preferences for the tools they want included in the final suite. What is needed now is to identify a final subset of tools that meet the $34 billion requirement—which is about $2 billion per year—that also receive strong support from the different stakeholders involved. Based on Table 4.6, the most popular options include parking levies, fuel taxes and sales taxes. It is not surprising that the final set of revenue tools put forward by Metrolinx include (O’Toole, 2013):

1. 5 cent per liter fuel tax ($330 million annually);
2. business parking levies ($350 million annually);

3. 1 percentage point increase in the Harmonized Sales Tax ($1.3 billion annually);

4. and 15% development charges ($100 million annually).

The four tools above provide the revenues required to meet the $2 billion per year requirement. The first three tools are also supported by the main stakeholders listed in Table 4.6, except for sales taxes which was not considered a top 6 choice for participants of the Toronto Talks Transportation series (it was ranked 7 out of 14). Raising fuel taxes has been discussed earlier in this thesis, which is suggested as one option to finance the U.S. transportation system since it can encourage less driving and the adoption of more efficient vehicles (Karplus, 2013). Similarly, parking levies can both raise revenues and reduce congestion (Litman, 2013). Although a small revenue source, using development charges was chosen, perhaps due the current construction boom as reported in Urban Toronto (Leal, 2013).

Increasing the sales tax generates substantial revenues, but Schweitzer and Taylor (2008) warn that this option may be more regressive compared to a congestion toll. Using data from the State Route 91 in Orange County, California, Schweitzer and Taylor (2008) find that low-income motorists save substantially as individuals if they are not charged tolls, but low-income residents as an entire group pay more with sales taxes on average. Nevertheless, these four revenue sources spread the costs across all parties (see Table 4.5). Not only are they considered fair and equitable, but GTHA residents also find them transparent and see how they can improve the transportation system (MASS LBP, 2013). More importantly, these tools could be used as dedicated revenue sources—they could be depended on to support the future of The Big Move.

Congestion charging received some support from the public consultation process, but the City of Toronto did not support this as an option to fund The Big Move (CoT, 2013):

A congestion levy did get very high support in the public consultations and on-line survey, perhaps due to its high profile and perceived successful implementation in London England. However, a congestion levy or cordon charge for
vehicles entering a prescribed downtown area would hurt investment in Toronto, and penalize compact urban transit friendly urban form. It is also contrary to the recommended principle of generating revenue across the region.

Metrolinx did not pursue congestion pricing, perhaps due to its low political support. More importantly, the decision they were facing was to select revenue tools, with the focus on revenue generation and not on congestion reduction. Hence, not including congestion pricing in the tools to fund The Big Move appears to have been the right choice. In any case, the decision-making process employed by Metrolinx is appealing for a number of reasons:

1. Metrolinx engaged the public throughout the process, educating them about the cost of congestion, transportation funding and the importance of public transit.

2. Metrolinx was able to increase the public's trust on them by showcasing transportation projects that have already been funded and are underway, which include subway expansions as well as new light rail and bus rapid transit services (Metrolinx, 2013c,a).

3. Some sort of consensus across various stakeholders were sought, as reflected in the chosen tools that spread the costs across multiple stakeholders.
Chapter 5

Conclusion

5.1 Congestion Pricing and Public Acceptance

The accessibility provided by a transportation system that sufficiently meets travel needs is an important backbone of any attractive, vibrant and economically healthy city. Unfortunately, the freedom to use the transportation system at one's convenience—although individually desirable—often leads to congestion on roadways or overcrowding in the transit system. Road congestion, one of the many externalities from automobile dependency, imposes substantial costs on society through longer commute times, wasted fuel and increased environmental emissions. Congestion affects not only individual motorists, but also impedes bus and other surface transit services, as well as goods movement. Expanding the transportation system costs money, and appears challenging given growing funding concerns (Wachs, 2006). Furthermore, building more roads seems counterproductive, since this has been shown to induce even further traffic over the long-term (Duranton and Turner, 2011).

Congestion pricing is an efficient, market-based response to mitigate traffic congestion that is being explored in many metropolitan areas around the world. It is appealing since it can both mitigate congestion by managing demand, while simultaneously providing revenues to improve accessibility (Balducci et al., 2011). However, a central debate with regards to CP is that of social versus individual welfare (Levinson, 2010). While reducing congestion benefits society as a whole, pricing necessitates imposing costs on individuals and restricting personal mobility, whether it be through paying tolls, switching from preferred routes or modes, or suffering indirectly due to the behavioral responses of others (e.g., rat running)
(Wohl and Hendrickson, 1984). Although congestion pricing has enjoyed operational success in a number of major cities (e.g., London, Stockholm and Singapore), there have also been high profile rejections of CP proposals (e.g., New York City, Edinburgh, Manchester and Hong Kong). Hence, despite the strong economic rationale behind pricing, public acceptance remains one of CP's main obstacles to implementation. Winning the public acceptance battle requires addressing four sources of public rejection.

First, minimizing any resulting inequity due to the introduction of CP is crucial. The distribution of costs and benefits of a congestion pricing program becomes paramount since this often determines who wins and losses after CP is introduced (Levinson, 2010). This consequently shapes the political support for and opposition against CP's introduction (King et al., 2007). Collective action by those adversely affected can prove to be significant opposition to CP (Albalate and Bel, 2009). For instance, the most vocal opponents against introducing CP in Manhattan were outer borough residents that were relatively auto-dependent and had the least convenient access to transit (Schaller, 2010). The redistribution of the congestion tolls collected is a critical step to compensate the losers due to CP (Lindsey, 2006). Equally important, providing sufficient transport alternatives helps ensure that personal mobility, along with business accessibility to customers and labor, is not restrained after CP is introduced. A strong transit base can also improve the acceptance of pricing, as was the case in London where there were many more bus passengers (and winners) than automobile users.

In addition to inequity, the uncertainty with regards to the program's benefits also affects public acceptance. For one, a credible commitment problem can exist, which is when the public distrusts that the government would redistribute the collected revenues back to them (Manville and King, 2012). In Edinburgh, Allen et al. (2006) notes that "only 16.8% agreed that 'the Council can be trusted to improve the welfare of Edinburgh residents.'" The complexity of the scheme design and technology can exacerbate this problem if these dimensions are not transparent enough for the public to understand. That is, the lack of transparency makes it difficult for the public to appreciate CP's benefits, especially when contrasted against visible congestion charges. Consider for instance that both the failed CP attempts in Manchester and Edinburgh proposed double cordon schemes, which are more complex that the single cordon schemes adopted in London and Stockholm.
Another source of public rejection is societal views on congestion pricing. This moderates the perceived inequity and uncertainty of the public regarding the program’s costs and benefits. Media coverage can influence societal views by framing the public’s perception of CP. In Manchester, media coverage focused on the congestion charging element, with little attention to the transport investments that accompanied the CP program (Vigar et al., 2011). Likewise, Edinburgh’s press coverage of CP was mostly of a negative tone (Allen et al., 2006). Equally important, the public perception of the congestion problem is crucial for garnering support (Albalate and Bel, 2009). A case to adopt CP can only be made if the congestion problem is indeed serious enough. Ison and Rye (2005) report that one of the reasons CP was rejected in Hong Kong was that congestion levels were not perceived to be severe enough by the public to necessitate such a radical policy.

Institutional issues are the final source of public rejection. For instance, Mayor Bloomberg required the approval of the State Assembly to introduce congestion pricing in New York City, while Mayor Livingstone had all the authority he needed to implement CP in London (Schaller, 2010). Without clear institutional authority, the political process then becomes the avenue in which those adversely affected can mobilize to stop the implementation of CP, which is often motivated by the collective action of those adversely impacted due to CP’s introduction. If there is a lack of a political champion, the uncertainty the public has about the program’s benefits can also worsen (Ison and Rye, 2005). When multiple actors are involved, a central issue then is who has control of implementation. This is particularly important when there is coordination needed among the available transportation alternatives and the program’s operations and scheme design (Mahendra et al., 2012).

A number of options exist that could be used to address these four sources of public rejection. One way to reduce problems related to societal views, uncertainty and inequity is adopting a strong public education and engagement campaign. Alternatively, demonstration projects and upfront investment in transit are additional ways to win the public’s trust in government. Earmarking the CP revenues to public transit also improves vertical equity issues. However, while demonstration projects and upfront transit investments can certainly increase public support for CP, these may be operationally difficult for public transport
agencies due to the lead times required to procure a new fleet and drivers. London provided 200 extra buses to serve the cordon area before CP was implemented (Banister, 2003), but this may have been due to its privately run nature with multiple bus operators capable of quickly expanding service—a flexibility that may not be afforded to public transportation authorities.

The road to public acceptance may also undermine the basic policy goals of congestion pricing, such as when making political trade-offs to achieve CP’s implementation. For instance, even though the Stockholm CP survived its 2006 trial and was implemented permanently in 2007, the political price to achieve support was to divert the hypothecated revenues to finance a new ring-road as this was believed to appease motorists (Börjesson et al., 2012). This could not only weaken agglomeration benefits to the core, but could also lead to further sprawl and worse congestion.

5.2 Should Congestion be Priced?

The successful examples of London, Stockholm and Singapore show that congestion pricing not only reduces congestion, but can also lead to other benefits, such as the reductions in traffic accidents and environmental emissions (Anas and Lindsey, 2011). In Stockholm, fare revenues increased since there was adequate transit to accommodate the passengers that shift from using their automobiles (Eliasson, 2009).

On the other hand, there are also negative impacts associated with CP. For instance, a report by Arup (2004) finds that parking revenues in Central London have dropped since the introduction of the congestion charge. If parking operators had reduced prices to compensate for the reduction in revenues, then pricing’s congestion reduction effectiveness could have been undermined. The London CP was also feared to have had a negative impact on retail sales, prompting some businesses to consider relocating outside the charging zone (Winsor-Cundell, 2003). Both impacts on parking revenues and retail sales show that CP might reduce the attractiveness of the core as a place to do business. Furthermore, when charges were initially set too high in Singapore, inefficient traffic allocation occurred where off-peak speeds in certain routes were slower than their peak counterparts (McCarthy and Tay, 1993).
Introducing congestion pricing requires generating substantial political support. Hence, it must be clear from the start that the severity of the congestion problem indeed warrants a policy like congestion pricing to be considered. Furthermore, both positive and negative impacts of CP need to be weighed when deciding to pursue this policy. Whether or not CP should be introduced depends on a number of factors. In particular, is the premier goal to reduce congestion or raise revenues? CP is primarily aimed at reducing congestion, and may not be an appropriate stable source of revenue. If the objective is the latter, then other transport policies might be more suitable for this purpose.

Another important question is whether the resulting inequities could be properly addressed? For instance, are there sufficient transportation alternatives (e.g., transit, non-tolled lanes, etc.) to accommodate those drivers who avoid the congestion zone or switch modes? Furthermore, what is the likelihood of success? That is, is there enough support for pricing across various stakeholders, and what sorts of legislative obstacles exist before the final decision is approved? These are tough questions, but whether or not pricing should be pursued always depends on the context.

In addition, the technology available and scheme design are important dimensions of this decision. For one, scheme design can be used to minimize any resulting inequities. Albalate and Bel (2009) note that in all experiences with congestion pricing, discounts were given to residents who were most affected. The available technology also enables the extent to which efficient pricing can be operationalized. However, the complexity of the scheme can be in tension with its effectiveness to reduce congestion. That is, while schemes that fully differentiate prices in real time are theoretically more efficient, they are limited by their transparency to the public who need to comprehend the price signals in order to response appropriately (Balducci et al., 2011). The costs of technology (e.g., capital, operating, collection costs) also influence the final amount of revenues generated that are available for redistribution.

Throughout this decision-making process, it is essential to keep in mind that CP is only one solution among a portfolio of options for transportation authorities. Other policies exist, which have their own revenue generation and congestion mitigation potentials. Although less
economically efficient, regulatory approaches should also be considered. These are not only often deemed to be fairer since they do not discriminate by willingness to pay, but they also have other benefits associated with them that could be used to achieve a variety of objectives. For example, pedestrian zones have shown to improve the quality of public spaces, making it more enjoyable to walk around due to less noise and better air quality (Topp and Pharoah, 1994). All these factors, particularly the political feasibility of each of the policy options available, should be weighed and integrated into a portfolio of congestion mitigation solutions.

5.3 Future Work

This thesis attempts to navigate through issues related to the adoption of congestion pricing. This includes examining the important policy dimensions of pricing, its sources of public rejection and any resulting impacts. Although the thesis aims to be comprehensive, a number of issues are not discussed. For instance, I do not tackle any of the technical challenges associated with predicting expected travel behavior changes due to CP’s introduction (Mahendra et al., 2012). Most models that are used to forecast travel behavior changes are based on stated preference surveys, which may not reflect what people actually do after CP is introduced. This is important since a sound equity impact analysis rests on the availability of good data and models. In addition, there are also interoperability issues with respect to the technology (Mahendra et al., 2012). A whole suite of other congestion mitigation solutions (e.g., high-occupancy vehicle lanes, staggered work hours, ramp metering, etc.) are also not discussed here.

There is also currently much discussion of the potential of network road pricing, as opposed to cordon-based pricing. With improved technology, network pricing may be feasible, but a thorough analysis is required to determine if it would be desirable. The approach used in this thesis can be applied to network pricing, as well as other congestion mitigation policies, to help answer these questions.

An area of future research that I am particularly interested in is how the introduction (or at least, the effort to introduce) congestion pricing affects the public’s psyche. For instance,
after an extensive public engagement process in Washington D.C., Swanson and Hampton (2013) find that:

1. "Participants were generally unaware of the details of how transportation is currently funded, including the fact that the federal gas tax has not been raised in nearly two decades and is not indexed to inflation."

2. "Support for raising gas taxes nearly tripled between the beginning and end of the forums, once people learned more about it and considered congestion pricing alternatives."

3. "People are more likely to support more obvious solutions—such as increasing gas taxes—than more radical approaches like congestion pricing."

Hence, while the decision to introduce congestion pricing deserves much consideration by itself, there may be benefits associated with simply discussing this option, particularly increasing both the public's education on and acceptance of transportation policies in general.
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