CONGESTION PRICING IN CITIES OF THE DEVELOPING WORLD: EXPLORING PROSPECTS IN MEXICO CITY

by

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Abstract

Car ownership in many large cities of the developing world is rapidly increasing with rising incomes, and is accompanied by traffic gridlock, travel delays, and deteriorating air quality. The policy of congestion pricing to manage growing travel demand has been implemented with varying degrees of success in some developed countries. This thesis explores the applicability of congestion pricing in the Mexico City Metropolitan Area (MCMA).

Current transportation policies in the MCMA were studied, with an analysis of the factors causing increased demand for private transport. Of the many forms in which congestion pricing may be implemented, we focused on the possibility of a central city congestion zone similar to that recently implemented in the city of London, providing arguments for its viability, and preliminary analyses regarding potential impacts. We studied how household level car ownership had changed for different income groups in Mexico City between 1994 and 2000, in order to make empirical estimates of the distributional impacts that a congestion pricing scheme might have. Our results show that the location of low income car owning households far from the central areas, and their limited access to efficient public transport creates negative consequences for them. Yet, significant overall reductions in traffic and travel time savings are possible with a congestion charge. Lower income people can benefit if the revenues from congestion pricing are used to improve their accessibility to public transport.

Congestion pricing is difficult to implement, especially given the decentralization and overlapping levels of political authority in the MCMA. As part of this research, we surveyed various Mexican government officials, academics, researchers, and practitioners interested in improving transportation and air quality in the region. The survey shows that there is hesitation in considering any such policy in the MCMA without prior improvements in public transport.

In light of these findings, we have outlined the complicated issues surrounding implementation, with recommendations for a course of action given the current policy agenda. The findings presented in this thesis can be used by decision makers in Mexico City to design a set of policies for improving mobility, with a better understanding of the issues surrounding congestion pricing.

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CHAPTER 1. INTRODUCTION

1.1. Context

Traffic congestion is a growing problem affecting people’s quality of life in large cities, in both developed and developing countries. With growing car ownership, increasing distances traveled, and rapidly saturating road capacity, cities are faced with the dilemma of either imposing controls on automobiles, or suffering congestion.

The economic costs of congestion, in terms of time and money, are undoubtedly high. In its latest report on urban mobility in the United States, researchers at the Texas Transportation Institute used indicators from the 75 largest cities in the country to reveal alarming statistics. They estimated that congestion costs were $69.5 billion in the US in 2001, in terms of 5.7 billion gallons of wasted fuel and 3.5 billion hours of lost productivity resulting from traffic jams1. This cost had risen about 7% from the previous year. This is in spite of the fact that the United States has the second highest number of kilometers of major roads per 1000 persons in the world, next only to Canada.

In most large cities of the developing world, transportation demand and consequent road congestion have already reached a critical stage. Yet, governments are stalling in implementing policy and planning measures to deal with this situation for a number of reasons. One is the lack of sufficient resources to make large infrastructure investments. Another reason is the lack of institutional coordination between agencies responsible for financing, managing and operating urban transport. A third reason is the lack of political will to control private vehicle demand, given that it is usually the most influential socio-economic groups that have the largest share of private travel demand, and the highest trip rate. Thus, automobile ownership is growing with increasing population size and rising income in developing cities, leading to unsustainable motorization rates.

1 Lomax and Schrank (2003)
Other problems in cities of the developing world, such as increasing green house gas concentrations, air pollution, high accident rates, and urban sprawl, are all fallouts of rapid motorization, with more serious long-term consequences. These cities are highly populated, financially constrained, dense and heavily built-up. Therefore, the answer lies not only in building more infrastructure but rather, in managing existing road space with more discretion. Along with making investments to manage the existing transport infrastructure and services, improved methods of financing these investments must also be deployed. Congestion pricing is a policy of charging private vehicle users for the costs of transportation facilities provided to them at public expense, and it therefore helps raise revenues for a city.

The concept of congestion charging or value pricing involves rationing road space through pricing in order to distribute travel demand more evenly across available road capacity and times of day. It involves charging a fee for the use of existing infrastructure such that those who value it more end up paying more. The revenues raised can be spent to improve public transport in the city to accommodate those car drivers who change their travel behavior and move to public transport as their mode of choice, or drive at a different time of day. Singapore was the first country in the world to attempt this policy through its Area Licensing Scheme (ALS). Established in 1975, the scheme allowed private vehicles to enter congested downtown areas in the morning peak hours only if they had purchased an Area License. Changes have constantly been made to the system and since 1998 it has been upgraded to an Electronic Road Pricing (ERP) system to allow differential charging according to time of day, traffic speed, location, and evolving traffic conditions. For this, all private vehicles are fitted with transponders that allow automatic deduction of charges when the vehicle is driven under gantries installed on certain corridors.

Congestion pricing is a part of policies under the broader category of road pricing. There are other examples where urban road pricing has been implemented, such as in the cities of Norway and the United Kingdom. The Norwegian cities did not charge people for congestion to start with. The fee began as a toll to finance the roads, but is now being
modified to become a congestion charge. After close to three decades, the only other large city to successfully implement this policy is London. Congestion charging was implemented in London in February 2003, as an area-based scheme.

As part of the scheme, vehicles entering Central London during the major part of the day on weekdays are charged a flat daily fee. When they enter the congestion charging zone, their license plate numbers are read by cameras installed along the zone periphery and within it. Vehicle owners have to register their vehicles in advance and have to pay the charge when they enter the zone.

Many large cities of the world that suffer the same congestion problems as London have been keenly observing the London experience. The scheme is currently regarded as a success in reducing road congestion and travel delays. Moreover, the mayor who implemented it, Ken Livingstone, has recently been re-elected for another term (June 2004), confirming the political viability of the scheme. The first year of implementation of the London Congestion Charging Scheme has provided a valuable opportunity to observe the short-term impacts of the policy. However, since England is a high-income country, the lessons from London are not directly applicable to a developing country case. It is worth investigating congestion pricing for cities in the developing world because the policy presents an opportunity for those developing countries with adequate financial and staff resources to "leapfrog" forward in solving their urban transport problems.

1.2. Motivation

Mobility is a key determinant of personal and economic productivity in congested urban areas. Worldwide travel demand has grown to the extent that the global transportation sector is likely to become the leading user of non-renewable energy resources over the next 20 years. Statistics show that between now and 2020, the energy demand for transport is expected to grow by approximately 1.5 per cent per year in industrialized
countries and by 3.6 per cent per year in developing countries, with fossil fuels dominating 90% of the increase in demand.\(^2\)

Correlations between per capita GDP and the amount of passenger car travel per capita, drawn by the International Energy Agency for many countries show that growth in transport demand is closely linked with income growth. Especially, in the developing world, demand for private motorized transport expressed by say, per capita kilometers traveled, is steadily on the rise, with few, if any, signs of saturation.

This current pattern of travel behavior is inducing rapid suburbanization in less developed regions of the world, following the paradigm of industrialized countries. It has resulted in the emergence of huge but less dense cities, or cities that have developed multiple business districts that have grown parallel to, and in some cases, much faster than the central business districts. Increasing investments are made to service this growth with more road links. The lower density and more polycentric character of cities is leading to higher trip rates for passengers and freight over longer trip distances. Many cities in the developing world are struggling with the rapid growth in their fleets of motorized vehicles, and exactly how they address the rising demand for urban transport will have important implications for their environment and economic productivity. In this regard, congestion pricing can be a promising method to achieve many goals that the largest developing cities, such as Mexico City, are trying to fulfill with respect to sustainable urban transport. Chief among these are:

1) **Stabilizing motorization rate** – Different travel demand management measures such as creating exclusive public transport and pedestrian zones, increasing car ownership costs, and pricing, usually help restrict use of private automobiles. These measures can in the longer term also facilitate reduction in the rate of growth of motorization. Pricing has equity impacts that can be balanced by investing the revenues generated from higher income drivers to improve public transport for lower income users.

\(^2\) International Energy Agency (2002)
2) **Reducing pollution from emissions** - Increasing motorization is directly responsible for rising pollution in these cities. Deterring people from using private vehicles through imposing charges can reduce emissions and greenhouse gas concentrations too. This is especially important for Mexico City, which is amongst the most polluted cities in the world. Of course, as will be explained later in this thesis, the difficulty lies in convincing people of the benefits of not driving a car they have already bought.

3) **Encouraging use of public transport** – It is widely recognized that a high quality public transport system is essential to improve mobility, and to limit the growth rate of private vehicles by providing an efficient travel alternative. Large cities in the developing world are increasingly investing in state-of-the-art public transport systems such as Mass Rapid Transit (MRT) or Bus Rapid Transit (BRT) that will require maintenance and capacity enhancements in the future. Congestion pricing can provide funds for implementing and expanding public transport projects. A new BRT project has recently been approved in Mexico City too.

4) **Increasing financial capability to invest in public infrastructure** – Many developing cities are aided by international donors or multilateral agencies in building public infrastructure. But in cities where economic growth is high, privatization is changing the trend. Public-private partnerships are commonly established for financing infrastructure projects. Congestion pricing operations can easily fall into this type of partnership, while increasing the city’s revenues to invest in public infrastructure.

The problem remains that there are no precedents of the policy in the developing world. The long-standing case of Singapore and the recent experience of London demonstrate that these area-based pricing schemes have had successful results. However, we can only draw some guidance from these cases. Most of the problems that will be encountered in implementing a congestion charge in the Mexico City Metropolitan Area (MCMA) have not risen prominently in the cases of London or Singapore.

First of all, the lack of efficient public transport, especially buses, would create negative distributive impacts of a pricing policy for lower and middle-income households in the
MCMA. Another prominent issue is that of an equity imbalance, whereby a poor person would spend a higher proportion of income on a congestion charge than a rich person, to access the same area of a city. The equity consideration also arises because it is lower income people who usually live farther away from centers of employment and they are forced to own and drive cars in the absence of other alternatives. Other conditions likely to impact implementation are conflicting institutional bodies, jurisdictions and decision-making powers. In developing countries, the resources to execute a pricing scheme would usually compete with other causes deemed to be more important, especially with regards to political will. In addition, enforcement of traffic laws and registration procedures is limited.

A unique factor in Mexico City is the significance of privately operated fixed route public minibuses or colectivos that enjoy high passenger mode share. There is a feeling of insecurity associated with using these minibuses, the Metro and even taxis. In addition, the current policy agenda favors construction of additional road space to accommodate the ever-increasing private vehicles and colectivos in the city. All these factors spin off many issues regarding public acceptability of congestion pricing.

The aim of this research, therefore, is to explore congestion pricing as part of a set of policy actions to manage the growth and use of private automobiles in Mexico City. Congestion and travel delays affect quality of life in a significant way; similarly air quality has important impacts on public health and mortality. Recognizing that 70% of the air pollution in Mexico City is attributed to the transportation sector, this research may offer an approach to deal with the two externalities of congestion and pollution with one idea.

1.3. Assumptions and Hypothesis

We begin with the assumption that theoretically, congestion pricing is a viable idea to reduce the negative impacts of high motorization, travel delays and congested traffic. This is based on the notion that road space is yet another infrastructure resource provided to people at public cost that tends to be over-exploited. Given that people pay for their
water supply, electricity supply, and telecommunications services according to the level of use, it is possible that user fees can similarly be charged for better traffic conditions and road use. If such a policy is in place, people will pay only for the number of times they drive into the most congested parts of a city. If they choose to do this everyday, they will pay more. If they choose to car pool or use public transport for the days that they don’t necessarily need the flexibility, then they will pay less.

In case of congestion pricing, people pay for intangible entities such as a smoother flow of traffic and reduced travel delays, as against utilities such as water, electricity, gas, and so on, where they pay for something tangible. However, because people are accustomed to using road space for free, road pricing is bound to generate opposition. If a charge for driving into downtown areas had been in force from the start, first of all, traffic conditions would not be as critical as they are today, and second, less utility would be attached to car ownership than at present. Since a free resource is always over-exploited, traffic congestion has been intensifying in recent years, and drastic measures to manage it have now become imperative. This is especially true in fast-growing cities of the developing world where motorization rates are growing rapidly due to the perception that owning a car is a status symbol, and due to the poor condition of public transport.

In this study, we address issues of how applicable congestion pricing is in the developing world, keeping the distributive impacts in mind. The hypothesis is that despite the problems described above, the policy is bound to result in many benefits and can be implemented in an equitable way. This would be as part of a package of complementary measures that is politically feasible. What is equitable is subjective of course. But if it can be proved from a particular policy design that the net economic benefit to the city, especially from the point of view of the disadvantaged sections of the population, is higher than the monetary, time, and inconvenience costs incurred, then we would be closer to a social optimum. A carefully considered value for the congestion charge, redistribution methods, user-friendly charge payment technology and public transport improvements must be adopted as part of the package of measures, for a more acceptable implementation of congestion pricing in developing world cities.
The MIT Integrated Program on Urban, Global and Regional Air Pollution has supported research on road-based public transport (Darido) and transit-oriented development (Gilat) in Mexico City. This thesis deals with a package of measures centered on congestion pricing that complements these research themes.

1.4. Thesis Objectives

1) To explore the applicability of congestion pricing in Mexico City by understanding potential benefits and constraints to implementation
2) To determine how congestion pricing might fit within the current transport policy and planning agenda, with an emphasis on building public and political acceptability.
3) To recommend complementary measures, institutional responsibilities, and use of revenue.
4) To assess possible distributive impacts by anticipating the responses of stakeholders.

1.5. Research Questions

Since there is no successful example of congestion pricing in developing economies, the questions addressed in this thesis provide a model of inquiry for other cities. These include:

- What are the factors causing high motorization and traffic congestion in Mexico City? Would congestion pricing be effective in improving urban transport? If so, what are the potential impacts?
- What are the different ways in which congestion pricing has been implemented around the world, and what would be the best option for Mexico City?
- How can congestion pricing be packaged with other policy measures to address equity issues, implementation challenges, and to produce long term benefits?
- How can the various stakeholder interests be addressed to make the policy publicly and politically acceptable in Mexico City?

We begin by studying the city’s urban context and key transportation indicators, described in the next section.
1.6. Contribution to Existing Literature

There is a large body of existing literature on the theoretical principles of congestion pricing, its various distributive impacts, and the challenges to implementing it. However, practical applications are very few, with the key examples being in Singapore, London, the Norwegian cities of Oslo, Trondheim and Bergen, and the examples of High Occupancy Toll (HOT) lanes in San Diego and other North American cities. These schemes differ considerably in their features and implementation. The characteristics of the urban areas they are applied in are also very varied. All these cases are based in cities of the developed world and most have been well documented, permitting analysis. This is especially true of the London scheme that is under observation by many other cities, such as Paris, in order to draw lessons for designing a similar policy.

However, there is no literature that draws lessons from these schemes, seeks to alter and adapt them, and ascertain the feasibility of implementation in the more challenging context of a mega-city in the developing world. The Mexico City Metropolitan Area (MCMA), for example, has a population size that is about triple that of London, far fewer local government resources, and more critical levels of traffic congestion due to mixed modes on the streets. It has high traffic-related air pollution and a vehicle fleet that is growing at a very fast rate. The institutional responsibilities are conflicting, and the current policy agenda favors the construction of more road space to fulfill growing demand, rather than policies to manage excessive travel demand. It has been proved time and again and in varied contexts that adding more road space only leads to temporary and short-term congestion relief. In the medium and longer term, it induces more demand and fuels the need for more infrastructure. This is clearly not a sustainable path to follow; yet the high visibility of large infrastructure projects usually makes them lucrative for building a political agenda or campaign.

Given these challenges, this thesis shows how congestion pricing might be applicable in the context of Mexico City, with recommendations for how it might be implemented. Urban areas in the developing world may be most in need of policies such as congestion pricing, yet the policy has not been explored in these contexts due to the implementation
challenges anticipated, and the lack of data. This thesis will contribute to the current body of literature in that it will provide the first such study for the MCMA, and will be among the few studies done for a developing city. Many large developing cities have the same social, economic, institutional and political environment as Mexico City, thus this research can provide some direction for similar work in other contexts.
CHAPTER 2. BACKGROUND INFORMATION ON MEXICO CITY

With a population of 18 million today, the Mexico City Metropolitan Area (MCMA) is considered one of the four largest urbanized areas in the world, along with New York City, Tokyo and Mumbai. Unofficial estimates of the MCMA’s total population size are even higher, going up to 20 million.

The city exemplifies the “leviathan”\(^3\) nature of many metropolises in the developing world that are growing rapidly in size, scale and population. The term ”mega-city” has also been used to describe the Mexico City Metropolitan Area that includes within it the 16 delegaciones (or boroughs) of the Federal District (Distrito Federal - DF), 37 urbanized municipalities from the surrounding State of Mexico (Estado de Mexico - EM) and one municipality from the state of Hidalgo. The DF and the EM both have their own self-governing administrations. The Federal District (DF) is considered the central business district of the region and contains the historic city center, the Zocalo.

The MCMA is situated in a valley, at an average altitude of 2,286 meters, covering an area of 4,945 square kilometers. The high altitude causes incomplete fuel combustion, while the surrounding mountains impede air circulation to make the MCMA an air pollution sink of sorts. The complete sphere of influence of the MCMA, referred to as the “megalopolis” by Molina and Molina (2002), extends to about 75 to 150 kilometers from the city center, and includes six cities that surround the MCMA in a ring known as the corona or crown. These include Puebla, Tlaxcala, Cuernavaca, Cuautla, Pachuca, and Toluca, all of which are metropolises themselves. The megalopolis has a total population of 25 million, representing over a quarter of the nation’s population\(^4\).

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\(^3\) Davis (1994). “Urban Leviathan” is the term used by Davis to describe Mexico City in the Twentieth Century.

\(^4\) Molina, Molina and Alliance for Global Sustainability (2002)
2.1. Population Growth Trend

Population in the MCMA is growing at an average rate of 2% per annum and is estimated to reach 26 million by the year 2020. The DF has a 30% share of the entire urbanized area of the MCMA but had only 0.3% average annual growth in population between 1995 and 2000. In contrast, the suburban municipalities in the State of Mexico (EM) had about 3% population growth in the same period with most of the growth occurring in the municipalities north and east of the DF. This high suburban growth is expected to

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5 Molina and Molina (2002)
6 COMETRAVI (1999)
increase further in the years to come. While the absolute population of the MCMA has almost tripled between 1970 and 2000, increasing by 195%, the urban land area increased even more, by 226%\(^7\). Thus, more people are spread over a larger urban area today. Figure 2-2 shows the growth of the metropolitan area as it has expanded into the surrounding State of Mexico.

**FIGURE 2-2 Growth of the Mexico City Metropolitan Area**

![Growth of the Mexico City Metropolitan Area](image)

*Source: Presentation by Mario Molina, Seventh Workshop on Air Quality in Mexico City, 2004*

The DF and EM had roughly an equal share of the population in 1995, but by the year 2020, the EM’s share is expected to be double that of the DF. The city center lost population at the rate of about 2% between 1970 and 1995\(^8\). The rapid decentralization in the MCMA since 1960 is evident from the loss of population from the central city to the suburban areas in the State of Mexico as shown in Figure 2-3.

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7 Villegas-Lopez (2001)
8 Molina and Molina (2002)
In spite of this trend, overall average urban density in the MCMA is high at about 12,000 persons per square kilometer. The figure for urban density actually ranges between 5,000 and 15,000 persons per square kilometer, usually reducing with increasing distance from the Zocalo (central city). However, some high-density areas are located much further away because roughly 62% of the MCMA’s population is concentrated in irregular low-income settlements typically occurring on the city’s outskirts.

2.2. Urban Structure and Expansion

Decentralization of Mexico City has been exacerbated in recent years due to many causes. One reason is the environmental degradation, particularly atmospheric pollution and traffic congestion in the central areas that has increasingly caused more affluent people to leave the city since the 1980s. Increasing commercial activity accompanied by high land-values is another cause of decline in the central city’s population. Land values

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9 Gakenheimer and Zegras (2003)
10 Connolly (1999). Apparently, decentralizing Mexico City, Guadalajara and Monterrey figured as a goal in national urban development programs since the first one, in 1976, with the reasoning that the as more people moved out of the core of the city, it would result in more sustainable urban development with improved environmental conditions.
have become very high in these parts and are on average about three times higher than those in the periphery of the DF. Lower income households, especially, cannot remain in the central city and are forced to build or rent homes in peripheral areas. After an earthquake devastated Mexico City in 1985, the DF government undertook major reconstruction of the central areas, providing subsidized low-income housing, still these areas are losing population.

The government’s General Program of Urban Development for the DF\textsuperscript{11} describes four distinct zones of current and future development. These include the city center at the core, which will remain the center of business and services. The first ring around it represents a high quality and well-serviced zone, the second ring represents a transitional zone, and the third ring is essentially a rural zone fast becoming part of the metropolitan area. At present, population of the MCMA is concentrated within the first ring, but the outer rings are experiencing the fastest growth.

2.3. Economic Characteristics and Income Distribution

The per capita Gross Domestic Product (GDP) of the MCMA has been estimated at about US $7,500 in the year 2000, contributing a third of the GDP of the country\textsuperscript{12}. The MCMA’s economy shifted significantly from manufacturing activities to services. In 1998, 76\% of the MCMA’s GDP was generated in the services sector, followed by 19\% generated through industrial activities. 70\% of the labor force of the MCMA works in the services sector, 29\% in manufacturing and 1\% in the agricultural sector\textsuperscript{13}. Income disparities in the metropolitan area are high, and the wealthiest 10\% of the population possesses 20 times more income than the poorest 10\%\textsuperscript{25}. The DF has GDP per capita about three times higher than the EM\textsuperscript{26}. In comparison with Mexico’s average GDP per capita, the DF’s GDP per capita was 135\% higher, while the EM’s was 19\% lower\textsuperscript{15}.

\begin{thebibliography}{10}
\bibitem{11} SEDUVI (1996)
\bibitem{12} Villegas-Lopez (2000)
\bibitem{13} Ibid.
\bibitem{25} Gakenheimer and Zegras (2003)
\bibitem{26} INEGI (2000) - GDP per capita in the DF in the year 2000 was US$13,089, nearly three times higher than that in the EM (US$4,542)
\bibitem{15} Bracamontes (2003)
\end{thebibliography}
In addition, there is a clear pattern of socio-economic spatial segregation, with lower income households occupying mostly the north and east parts of the city and wealthier households occupying the south and southwest parts. Major shopping centers are located in the west and southwest parts, while the relatively poorer north and east parts in the State of Mexico have a higher concentration of industries, less access to services and more traditional commercial areas\textsuperscript{16}. Figure 2-4 shows this pattern.

\textbf{FIGURE 2-4  Land Use in the MCMA (1997)}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure2-4.png}
\caption{Land Use in the MCMA (1997)}
\end{figure}

Source: Adapted from Gilat (2002)

\textsuperscript{16} Gakenheimer and Zegras (2003)
On comparing Figure 2-5 below with the land use map in the previous figure, it is evident that most lower income households are located to the northwest and northeast of the CBD, in parts of the State of Mexico where the industries are concentrated.

**FIGURE 2-5  Spatial Segregation by Income in the MCMA (1990)**

17 Schteingart (2000)
2.4. Transportation Infrastructure and Travel Demand in the MCMA

In Mexico City, there is a stark disparity in the availability of transportation infrastructure between the Federal District (DF) and the State of Mexico (EM). This is true for public and private transport. For example, available data show that the annual investment in transportation infrastructure in the DF was US $1000 million in 1992, while it was only US $80 million in the EM\textsuperscript{18}. Table 2-1 below clearly illustrates this disparity.

**Table 2-1  Summary of Transport Infrastructure in the MCMA**

<table>
<thead>
<tr>
<th>Type</th>
<th>DF</th>
<th>EM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Roads</td>
<td>198.4 kms (67% controlled access)</td>
<td>352 kms highways</td>
</tr>
<tr>
<td>“Ejes” Viales</td>
<td>310 kms</td>
<td>47 kms (Vías Rápidas Urbanas)</td>
</tr>
<tr>
<td>Principal Roads</td>
<td>552.5 kms</td>
<td>616 kms</td>
</tr>
<tr>
<td>Secondary Roads</td>
<td>8,000 kms (8150)</td>
<td>250</td>
</tr>
<tr>
<td>Metro</td>
<td>178 kms</td>
<td>-</td>
</tr>
<tr>
<td>Trolleybus</td>
<td>377 kms</td>
<td>-</td>
</tr>
<tr>
<td>Light Rail</td>
<td>26 kms (13 in each direction)</td>
<td>-</td>
</tr>
<tr>
<td>Parking spaces</td>
<td>126,257 spaces (10,000 lots)</td>
<td>N/A</td>
</tr>
<tr>
<td>Parking Meters</td>
<td>1,535</td>
<td></td>
</tr>
<tr>
<td>Bus shelters</td>
<td>2,347</td>
<td>290</td>
</tr>
<tr>
<td>Contra-flow lanes</td>
<td>13 lanes/186 km</td>
<td></td>
</tr>
</tbody>
</table>

*Source: COMETRAVI (1999)*\textsuperscript{19}

Since the DF area contains the historic city center with old, narrow streets, it suffers from chronic traffic congestion. In addition, infrastructure investments have not kept pace with the growth in population and the more rapid growth in motorized vehicles. The DF and the EM have their own vehicle registration databases, both of which are poorly maintained, so estimates of the total vehicle fleet vary, even among the different government agencies. The total number of vehicles in the city range from 3 to 3.2 million, with cars making up 72% of the fleet, vans and pickups comprising 20% and the rest made up of buses and trucks. The percentage of cars in the fleet has been rapidly increasing with rising personal wealth, growing at a rate much faster than population growth.

\textsuperscript{18} Connolly (1999)

\textsuperscript{19} Molina and Molina (2002). p. 230.
The yearly vehicle fleet has grown at the rate of 10% in the period from 1976-1996, and according to census data from the year 2000, 40% of households in the DF and 30% of those in the EM owned at least one car or small van. The motorization rate in this period grew from 78 cars per thousand inhabitants to 166 cars per thousand inhabitants, increasing by over 5% per year\textsuperscript{20}.

**FIGURE 2-6   Motorization index in the MCMA**

\[ \begin{array}{|c|c|c|c|c|c|c|c|c|}
\hline
\hline
0 & 20 & 40 & 60 & 80 & 100 & 120 & 140 \\
\hline
160 & 180 \\
\hline
\end{array} \]

\begin{itemize}
\item Number of Motor Vehicles per thousand inhabitants
\end{itemize}

Source: *Comprehensive Program for Traffic and Transport, 2001-2010, SETRAVI*

A study done by the International Association of Public Transport (UITP) of mobility indicators in a hundred cities around the world revealed that Mexico City has the highest car density rate in the continent, with 353 passenger cars per kilometer of roadway. This is much higher than Los Angeles, which has one of the highest density rates in the United States, with 141 cars/km. It is thus, not surprising that Mexico City is also considered one of the most polluted cities in the world, with an annual carbon monoxide exposure level of 152 kg/person, compared with 106.7 kg/person for Los Angeles\textsuperscript{21}.

According to the metropolitan transport authority COMETRAVI, annual traffic externality costs are currently estimated to be $7 billion, with 85% of the costs attributed

\textsuperscript{20} SETRAVI – Comprehensive Program for Traffic and Transport, 2001-2010
\textsuperscript{21} UITP (2003)
to traffic congestion and accidents. COMETRAVI’s study\(^{22}\) has revealed other indicators of high congestion levels. 74% of road intersections in the city are very congested (LOS F – the highest grade possible, showing traffic flows in excess of road capacity), with speeds below 20 kilometers per hour during peak hours. Average vehicle speeds in some parts are reported to be as low as 9 kilometers per hour\(^{23}\).

Public transportation, in the form of buses and the Metro, is most accessible in the central areas of the Federal District, with the municipalities of the State of Mexico facing limited access. The chief transportation options available to people in the EM are either private automobiles, or the low capacity privately operated minibuses called colectivos. It is the rapid increase in private automobiles and growth in colectivo traffic that has contributed most to traffic congestion in Mexico City, especially on the routes leading from the EM to the DF and on multiple nodes within the DF. The number of colectivos has increased due to the failure of the bus system and lack of growth in the Metro network in recent years. Figure 2-7 shows that the colectivos currently have the largest passenger trip mode share in the city.

**FIGURE 2-7  Motorized Mode Share of Passenger Trips in the MCMA (1995)**

![Motorized Mode Share of Passenger Trips in the MCMA (1995)](chart.png)

*Source: Gakenheimer and Zegras (2003)*

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\(^{22}\) COMETRAVI (1999)

\(^{23}\) Cervero (1998)
The following figure shows the evolution of mode shares in Mexico City in the last two decades, showing a significant shift from medium and high-capacity modes to low-capacity modes.

**FIGURE 2-8 Evolution of Mode Shares in the DF (%)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Private Automobiles (%)</th>
<th>Taxis (%)</th>
<th>Colectivos/Minibuses (%)</th>
<th>Bus (%)</th>
<th>Light Rail, Trolley Bus (%)</th>
<th>Metro (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>11.8</td>
<td>7.5</td>
<td>58.6</td>
<td>4.4</td>
<td>14.3</td>
<td>0.8</td>
</tr>
<tr>
<td>1992</td>
<td>13.2</td>
<td>9.0</td>
<td>50.8</td>
<td>47.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>20.9</td>
<td>19.9</td>
<td>34.6</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>19.1</td>
<td>3.2</td>
<td>42.3</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Comprehensive Program for Traffic and Transport, 2001-2010, SETRAVI

2.5. Transport Emissions in Mexico City

Air pollution is a serious problem further aggravated by congestion, and low average speeds of traffic. About three-quarters of the road network in the DF has an average traffic speed lower than 20 km/hr, with traffic demand exceeding road capacity. In such congested conditions, all vehicles produce significantly higher emissions due to frequently starting, stopping and idling in traffic. In addition, the age of the vehicle fleet is an important factor leading to high emissions. Inspection and maintenance records of vehicles in the DF show that 15% of the taxis and colectivos were nine years old or older in 1999. Of the 1.15 million private cars inspected, a sizeable 43% were models older than 1991, when no catalytic converters were required in vehicles.\(^{24}\)

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\(^{24}\) Molina and Molina (2002)
Private cars and taxis produce the most pollutants per passenger trip in the MCMA. They are responsible for most of the carbon monoxide emissions, and the highest proportions of nitrogen oxides and hydrocarbons. Private cars produce over half the total pollutants in the metropolitan area as shown in the table below.

**Table 2-2 Mobile Sources Emissions Inventory 1997 (tons/year)**

<table>
<thead>
<tr>
<th>Source</th>
<th>Particulates</th>
<th>SO₂</th>
<th>CO</th>
<th>NOₓ</th>
<th>HC</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Cars</td>
<td>87</td>
<td>2,474</td>
<td>1,327,858</td>
<td>40,151</td>
<td>97,510</td>
<td>1,468,080</td>
<td>53.4%</td>
</tr>
<tr>
<td>Private Transit Operators</td>
<td>29</td>
<td>396</td>
<td>177,252</td>
<td>3,683</td>
<td>19,018</td>
<td>200,378</td>
<td>7.3%</td>
</tr>
<tr>
<td>Taxi Cabs</td>
<td>17</td>
<td>481</td>
<td>258,156</td>
<td>7,806</td>
<td>18,957</td>
<td>285,417</td>
<td>10.4%</td>
</tr>
<tr>
<td>State-owned buses</td>
<td>59</td>
<td>13</td>
<td>1,458</td>
<td>1,232</td>
<td>472</td>
<td>3,234</td>
<td>0.1%</td>
</tr>
<tr>
<td>Intercity and suburban buses</td>
<td>95</td>
<td>21</td>
<td>2,340</td>
<td>1,978</td>
<td>757</td>
<td>5,191</td>
<td>0.2%</td>
</tr>
<tr>
<td>Privately operated buses</td>
<td>283</td>
<td>62</td>
<td>6,978</td>
<td>5,896</td>
<td>2,258</td>
<td>15,477</td>
<td>0.6%</td>
</tr>
<tr>
<td>Light weight trucks</td>
<td>107</td>
<td>1,459</td>
<td>653,318</td>
<td>13,575</td>
<td>70,096</td>
<td>738,555</td>
<td>26.9%</td>
</tr>
<tr>
<td>Heavy weight trucks</td>
<td>535</td>
<td>246</td>
<td>13,774</td>
<td>11,639</td>
<td>4,457</td>
<td>30,651</td>
<td>1.1%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,212</td>
<td>5,152</td>
<td>2,441,134</td>
<td>85,960</td>
<td>213,525</td>
<td>2,746,983</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

% Private Cars 7.2% 48.0% 54.4% 46.7% 45.7%


The environmental and transportation agencies in the MCMA have made considerable efforts towards improving air quality in the city. The Hoy No Circula (No Driving Day) program was an important step in this direction. It was instituted to ban cars older than 1993 from circulation on at least two days of the week and cars with catalytic converters but older than 1999 on one day of the week. This program has had mixed results, but the metropolitan environmental authority is planning to modify it to make it more stringent with stricter enforcement.

The latest strategy for improving air quality (PROAIRE – 2002-2010) in the MCMA includes many measures related to transportation that are required to be implemented before 2010. These include introducing low-emission buses, substituting old taxis and colectivos, expanding the metro, light rail and trolley network, and constructing more roads to ease congestion. However, the implementation of these measures depends upon the respective institutions in the EM and the DF.
2.6. Institutional Structure

The institutional structure in Mexico City is complex due to the presence of different overlapping levels of government. These consist of the Federal government, the governments of the Federal District (DF) and the State of Mexico (EM), and the Metropolitan government, for each area of intervention – transportation, land use, and the environment. Local governments such as those of the municipalities in the EM and delegaciones in the DF, international funding organizations, the private sector, especially infrastructure firms, private banks, real estate companies, universities, NGOs, labor unions, and private transit operators, are other actors playing active roles in the land use and transportation system that Mexico City represents.

Of the metropolitan organizations, while the metropolitan environmental commission (CAM) has considerable powers, the metropolitan transportation commission (COMETRAVI) usually has limited decision-making power as it suffers from conflicts between the EM and the DF. It is therefore, not effective in implementing policies, even though it conducts detailed studies on the MCMA’s transportation system that inform policy-making. The transportation agencies of the DF (SETRAVI) and the EM (SCT) invest in their own jurisdictions with little coordination. For example, while the SETRAVI acknowledges that the metro network needs to expand into the EM on the north and northeast, it is not able to proceed due to the limited funding contribution of the EM. The federal transportation agency, the Secretariat of Communications and Transport, is actively involved in infrastructure construction, and is responsible for traffic management and toll collections in the MCMA. In considering the application of congestion pricing in the city, it is necessary to study the roles of the various institutions and their responsibilities in more depth. Since the institutions are tied to political jurisdictions, there is bound to be a conflict of interests that must be dealt with.

2.7. Current Projects and Policies on the Urban Transport Agenda

In recent years, efforts to improve transportation in the MCMA have culminated in the approval of several projects at the urban and metropolitan level. It is these projects which, when completed, will dictate the future of travel demand in the region, and of land use
developments. Thus, it is important to track the development of these projects not only to assess travel demand but also to see where a demand restraint measure like congestion pricing might fit into the current agenda.

Both the DF and EM governments, as well as the federal government have planned many large scale transportation projects. These range from construction of a third and fourth ring road, to building elevated toll roads, metro expansions, dedicated bus corridors, improving and installing traffic signals and parking meters, and so on. According to the Mayor’s ‘high priority’ actions for 2004, investments of over 47 billion pesos will be made in the city’s transportation system, of which 6.4 billion pesos will be invested in the maintenance of the Metro, 3 billion to roadway and bridge projects, 885 million to the RTP bus system, and 582 million to the environment\textsuperscript{25}. Extensions to the metro have been postponed since the year 2000 due to limited availability of funds for capital investments.

While the Mexican transportation authorities are investing in significant public transport improvements towards a general strategy of encouraging high capacity modes that can substitute travel by private modes, they are also actively investing in more roads and bridges to relieve congestion in the short term. Unless the public transport modes are made more attractive and private transport is made to bear its fair costs, it is unlikely that the motorization rate will stabilize. Some transportation projects, begun in the period 2003-2004 are described below, with their possible repercussions for congestion.

\ \textbf{2.7.1. Public transport}

In terms of public transport improvements, the DF proposes to extend three existing Metro lines, 4, 5 and 11, into the EM, and construct three new lines by 2020. Two Bus Rapid Transit lines are planned on the high demand corridors of Eje 8 Sur in the Estado de Mexico and Insurgentes Avenue in the DF. These are being funded by the World Bank and the United Nations Global Environment Facility and will be operated by private companies. Currently detailed modeling studies for these corridors are underway. To reduce truck traffic congestion in the busy DF areas, freight distribution centers or

\footnote{\textit{Reforma}, Tuesday, January 6, 2004}
‘logistics platforms’ are proposed on the outskirts of the DF\textsuperscript{26}, along with regulations to control freight traffic.

**Bus Rapid Transit**

The first phase of Bus Rapid Transit system in the city, called “Metrobus”, includes corridors along Insurgentes and Popocatépetl (Eje 8 Sur) avenues, and will begin operations in 2005. A total length of 200 km of bus corridors has been proposed. These metropolitan corridors will have segregated lanes in the center of the avenues as in Bogota, with pre-paid passenger boarding on high-platform buses with left-side doors. Bus stops will be located at intervals of 400 meters, and the buses will circulate at 20 km/hour\textsuperscript{27}. The DF government expects a ridership of 225,000-232,000 passengers a day on the Insurgentes corridor. The buses are meant to replace the *colectivos* on these corridors.

While the central lanes will be exclusively for the new buses, leading to one less lane for the other vehicular traffic, drivers will also gain the right lane that is used by *colectivos* at present, once they are replaced by the buses. The BRT corridors will be linked with the Metro network, and the *colectivo* routes that cross Insurgentes will serve as feeder routes. The DF government hopes to finish six routes by 2006, when the current mayor - Lopez Obrador’s term ends\textsuperscript{28}. This is another positive development with respect to creating better public transport alternatives in the city.

**Metro**

Efforts are underway to improve the accessibility of trip destinations in the DF for residents in the Estado de Mexico. With the completion of the new Metro Line B in the year 2000, the EM municipalities to the northeast of the DF have improved access to the central areas of the city, with the line ending just north of the central business district at Buenavista station. The high ridership of about 320,000 passengers per day on this line is evidence of significant suburban demand.

\textsuperscript{26} Molina and Molina (2002)
\textsuperscript{27} *El Independiente*, p. 18 - Saturday, September 6, 2003
\textsuperscript{28} *Reforma*. p. 1B - Sunday, September 21, 2003
Government documents for transportation plans up to the year 2010 contain various figures of investments in the metro. The chief priority is to invest in maintenance of the metro and metro stations. Secretariat of Transport and Communications has approved funding to acquire 45 new trains and equipment. The stations are being rehabilitated, for example, the Pantitlan Station in the DF, which is the largest in Mexico City and sees heavy passenger volumes each day.

In addition, the DF authorities are considering the application of smart cards to modernize fare collection on the metro network. This will be especially important to integrate fares between the public transport modes within the DF. This technology would be used in the Metro, city buses, light rail and trolleybuses, as well as the BRT lines planned for Insurgentes and Eje 8 Sur, and will help improve the image of public transport in the city.

Colectivos
The fares on colectivos and concessioned buses have increased by 25%, and taxi fares are proposed to be 20% higher in 2004. Fares on government operated public transport, including the Metro, light rail, trolleys and buses have not been increased\(^{29}\). The DF government is also taking aggressive action to substitute older buses, taxis and colectivos with new vehicle fleets that will have lower emissions. Not only are these changes expected to facilitate improvements in service and ridership, but the higher fares will increase the incomes of colectivo operators. The higher fares could help offset the increased costs of a congestion charge for colectivo operators, if congestion pricing is considered at a later stage. If discounts are given to the colectivos, these need to be considered carefully so as not to undermine the purpose of the congestion charge.

The perception of crimes and insecurity on public transport is high in Mexico City, thus other measures are being taken to increase the attractiveness of public transport, such as the installation of centrally controlled security cameras in metro stations with high

\(^{29}\) Reforma. Friday, January 2, 2004
passenger volumes such as Pantitlan station. Panic buttons will be installed in colectivo vehicles to improve passenger security and prevent assaults.

**Tren Suburbano**

The DF authorities have also begun the bidding process for the construction of a new suburban train (Tren Suburbano) that would run from Buenavista train station in the DF to the State of Mexico. The 25-km stretch would require an investment of US $600 million, distributed between the EM, the federal government, and private funds, with the DF only providing the necessary permits. The initial demand for the suburban train is projected at 320,000 daily passengers, with a trip time of 30 minutes, with service commencing in 2005. The Metro Line B is evidence that these investments in improving public transport linkages between the DF and the EM can potentially lead to a substitution of colectivo trips, thereby reducing the need for lower income passengers to depend on this mode.

**2.7.2. Private transport**

**Parking Meters**

Parking meters will be installed in the three central delegaciones of the DF- Benito Juarez, Cuauhtemoc and Miguel Hidalgo. The fare for parking meters in the DF will be 2 pesos per 15 minutes (US $0.80 for an hour). The delegacion Cuauhtemoc where the Centro Historico is located, is expected to collect 90 million pesos (US $ 9 million) in revenue annually, 80% of which would be used by the delegación to finance its various programs. This is an important step to initiate the ‘culture of paying’ for road space in congested areas. The second phase of the remodeling of the Centro Historico has also begun, which will include repair of streets and drainage systems, renovating the facades of historic buildings, improving the lighting, and removing street vendors. The DF government has been trying to evict street vendors from the Centro Historico for many years without success. The street vendors are low-income people who usually carry their merchandise in low-cost polluting private vehicles; thus they represent a group that

30 *Reforma*, October 15, 2003  
31 *Reforma*. Wednesday, January 14, 2004  
32 *Reforma*. Friday, January 16, 2004
stands to be disadvantaged by any possibility of congestion pricing. However, it can be argued that the Hoy No Circula program presents a far greater disadvantage in this regard by prohibiting the vendors’ livelihoods for one or two days in a week.

Construction of roads and highways

The current mayor of Mexico City favors significant investments in roads, bridges and highways. Ongoing projects include a system of elevated roads through the center of the city forming a 35-km ‘Metropolitan Corridor’ (Corredor Vial Metropolitano) linking the north and south of the city from Ciudad Azteca in the State of Mexico, to Xochimilco in the south of the DF. It will be built by 2005, and will run parallel to the Insurgentes Avenue. It is envisaged as an alternative to the Insurgentes, one of the most congested roads in the DF with an average speed of 18 km per hour during peak hours\(^3\). Other efforts to divert traffic away from the city center include the construction of a 148-km Outer Ring Road in the State of Mexico, linking the highways of Mexico City to those of the surrounding crown cities of Queretaro, Pachuca and Puebla. This privately operated regional highway will serve as the fourth ring road and will allow 600,000 to 800,000 vehicles per day to bypass the DF along the north-east quadrant of the MCMA\(^4\). A third ring road has already been partially constructed, with its northern portion operating as a toll road, about 25 km from the city center. These ring roads will be concentric with the existing Circuito Interior (Inner Ring Road) and the Periferico beltway around the DF, and are being constructed primarily to prevent inter-city traffic from passing through congested parts of the MCMA.

Road connections between the DF and the EM, as well as within the EM, will be improved along with installation of traffic signals to manage the disorderly traffic in the EM. There is also a proposal to build elevated toll expressways on the most congested facilities in the DF. Apart from these projects, the controversial Segundos Pisos project to build a second level over the Periferico and Viaducto roads is already under construction.

\(^3\) Reforma. Sunday, January 11, 2004
\(^4\) Reforma. Tuesday, January 13, 2004
The strong focus on building more ring roads and metropolitan highways in Mexico City is evident from the recent investment budget for transportation activities shown in Table 2-3. Most of these projects are currently being implemented, and have been described above. With 62% of the overall budget devoted to elevated, highways, roads and bypasses, it is likely that the steep growth in car use will continue in the MCMA. While it may be argued that some of these roads are essential to improve the links between the DF and the EM, those being constructed as a short-term approach to solve the city’s congestion problem will end up being congested themselves after some years.

<table>
<thead>
<tr>
<th>Transport Improvements</th>
<th>Investment (million pesos)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated highways</td>
<td>1,500</td>
<td>39%</td>
</tr>
<tr>
<td>Other highways and bypasses</td>
<td>889</td>
<td>23%</td>
</tr>
<tr>
<td>Metro</td>
<td>1,054</td>
<td>27%</td>
</tr>
<tr>
<td>New buses</td>
<td>155</td>
<td>4%</td>
</tr>
<tr>
<td>New trolleys</td>
<td>103</td>
<td>3%</td>
</tr>
<tr>
<td>New taxis</td>
<td>100</td>
<td>3%</td>
</tr>
<tr>
<td>New minibuses</td>
<td>80</td>
<td>2%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,881</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: SETRAVI - Comprehensive Traffic and Transportation Plan (2001-2006)

In his popular book ‘Stuck in Traffic’, Downs has described the triple convergence principle\textsuperscript{35} of traveler behavior that occurs when new highways are constructed. It comprises the effect of (i) drivers who used alternative routes earlier, switching to the new highway (spatial convergence), (ii) drivers who earlier traveled just outside the peak hours to avoid peak period congestion, starting to travel in the peak hours on the new highway (time convergence), and (iii) mode shift of some people from public transportation to cars due to higher speeds possible on the new highway (mode convergence). Triple convergence thus causes an increasing number of drivers to use the new highways, up to the point that they become congested to the same level that the alternate routes were.

\textsuperscript{35} Downs and Brookings Institution. (1992)
The one remedy that avoids the effects of triple convergence is if some form of road pricing is implemented. In that case, congestion charges or peak period road tolls would lead to a reverse effect, that of triple divergence. Commuters formerly using certain facilities would change their route, time of travel, or mode, if a congestion toll were introduced. Zone-based congestion pricing added to high parking charges will together represent a cost that is higher than the value of time for many commuters, thus deterring them from driving into the congestion zone. A distance-based charge on driving is inequitable for many people in Mexico City, because lower income households live far from the city center.

Table 2-4 summarizes the various transportation policies currently proposed in the MCMA. We see that while most of the policies on the agenda are complementary with congestion pricing, the one that is not, that of adding more capacity is also the one that demands the largest magnitude of public investment (see Figure 3-22).

### TABLE 2-4 Summary of Current Transportation Policies Proposed in the MCMA

<table>
<thead>
<tr>
<th>Current Policies on the Agenda</th>
<th>Potential Medium-Term Impacts</th>
<th>Complementarity with Congestion Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Suburban train line between DF and EM</td>
<td>Substitution of colectivo trips, improved access</td>
<td>+</td>
</tr>
<tr>
<td>2 Bus Rapid Transit corridors</td>
<td>New transport alternative, substitution of colectivo trips</td>
<td>+</td>
</tr>
<tr>
<td>3 Metro station rehabilitation and train maintenance</td>
<td>Increased reliability, improved image of public transport</td>
<td>+</td>
</tr>
<tr>
<td>4 Extensions of the Metro into the EM</td>
<td>Substitution of colectivo trips and improved access</td>
<td>+</td>
</tr>
<tr>
<td>5 Smart cards to integrate BRT and metro fares</td>
<td>More efficient transfers, lower costs, higher ridership</td>
<td>+</td>
</tr>
<tr>
<td>6 Fare increases on colectivos and private buses</td>
<td>Reduced ridership, increased income for operators</td>
<td>+</td>
</tr>
<tr>
<td>7 Renewal of bus, taxi and colectivo fleets</td>
<td>Improved level of service, reduction in emissions</td>
<td>+</td>
</tr>
<tr>
<td>8 Security features in Metro stations and colectivos</td>
<td>Improved ridership due to higher level of security</td>
<td>+</td>
</tr>
<tr>
<td>9 Installation of Parking Meters</td>
<td>Reduction in on street parking, increased revenues</td>
<td>+</td>
</tr>
<tr>
<td>10 Elevated roads, third ring road, Segundo Pisos</td>
<td>Increased speed, increased VKT, reduced congestion</td>
<td>-</td>
</tr>
</tbody>
</table>

Assuming that calculations to set the congestion charge are such that it accurately represents the marginal social costs drivers impose on society, the question for travelers would be whether they value their time more than the congestion charge or less. If their time value were higher, then they would pay the charge, and if not then they would choose to drive on congested roads. For those who value their time more, and also have relatively lower incomes, public transport would have to be efficient enough to not
restrict their mobility. A congestion charge would facilitate this by resulting in improved travel speed and reliability of road-based public transport. It is essential to convey to people that the congestion charge they would pay is the social cost of travel delays and congestion that each driver inflicts. Even if people are amenable to waiting in traffic, they impose costs on others that they must pay for.

A detailed explanation of congestion pricing, the economic and political issues surrounding its implementation, and the reasons it is a controversial policy, are discussed in the next chapter.
3.1. Growing Motorization in the Developing World

Automobile ownership is increasing worldwide, and most of the growth in the last two decades is occurring in the developing countries. This is no surprise because while average per capita incomes are far lower in these countries, the rate of growth in incomes is very high. With rising personal income, automobile ownership grows slowly in the beginning, and then reaches an income threshold beyond which it grows rapidly. Further rise in income again relates with slower growth in ownership because people at those income levels already own as many cars as they desired. Finally, a level of saturation is reached when almost all of the highest income population owns (and uses) automobiles. The classic S-curve representing this relationship is shown in Figure 3-1.

**FIGURE 3-1  Growth in Motorization with Income**

![Graph showing the relationship between personal income and automobile ownership with a saturation level.](image)

*Source: Gakenheimer (2003)*

If the relationship shown above were depicted by country, then many developing countries would be located in the steepest portion of the graph. Rapid economic growth and uncontrolled motorization in these countries in recent years has exacerbated conditions of congestion and air pollution. Today, many of the fastest growing urban

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areas in the developing world face a situation where traffic flows are fast approaching existing capacity. This phenomenon of ‘hitting the wall’\textsuperscript{37}, as it were, is shown in Figure 3-2, and is prevalent on a majority of links in the central districts of Mexico City.

**Figure 3-2** Congested Traffic Conditions: ‘Hitting the Wall’

```
<table>
<thead>
<tr>
<th>Travel Time on a road</th>
<th>Volume (Number of Vehicles on the Road)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freeflow Conditions</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```


### 3.2. Congestion Pricing: Economic Arguments

The benefits of congestion pricing are that it helps to reduce travel delays in congested areas, encourages use of public transport in these areas, artificially increases capacity leading to higher average speeds and higher business efficiency in moving people and goods, creates a better and safer environment for pedestrians and cyclists, helps reduce greenhouse gases and polluting emissions, and finally, generates revenue that can be applied to a variety of purposes.

Pricing aims at improving utilization of present capacity, rather than investing in construction of more roads. The latter is currently the case in Mexico City, with government investment directed toward road building activities, such as construction of second levels (*Segundos Pisos*) on two major urban highways as a congestion relief measure. It also aims at increasing the efficiency of surface public transport such as buses, by reducing travel delays for passengers. It raises revenues for the public sector, which can help reduce fiscal deficit, and be used toward improvements in transport

infrastructure, institutional capacity, or other welfare measures. The hypothecation of revenues is particularly important when considering congestion pricing, as it directly affects public acceptability of the policy.

In technical terms, congestion pricing is a means to distribute travel demand more evenly across road capacity and times of day, by charging people a fee for using urban roads. It is thus, a means to internalize the external costs of urban transportation, manifested mostly in traffic congestion, travel delays, and vehicular emissions. It involves rationing limited road space between public and private transport modes, to improve the efficiency of publicly provided infrastructure. In economic terms, the policy requires that people pay a charge to reflect the true costs of private vehicle use in congested urban areas. These ‘true costs’ represent the marginal social costs of time delays imposed on other road users, the externality costs of congestion, associated air pollution, road accidents, and continuing road operations and maintenance costs.

**FIGURE 3-3 The Economics of Congestion Pricing**

Source: Adapted from Salvucci

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Figure 3-3 shows the downward sloping demand curve for a typical urban road. The demand curve aggregates the marginal benefit that each traveler gains from using the road. Considering a fixed level of service, as traffic volume on the road increases, and more of the road’s capacity is used up, the marginal benefit reduces.

There are two distinct cost curves, one that is the marginal social cost curve, representing the costs to society of an extra vehicle on the road, and the other is the cost perceived by each individual, or the average cost curve. The cost considered here is the sum of all variable costs, time costs, and costs related with inconvenience caused to drivers on congested road conditions. As long as traffic on the road remains free flowing, the cost of an extra vehicle being added remains constant, represented by GH in the figure.

The value $Q_3$ represents traffic volume on the road when there is no congestion. As more vehicles are added to the road, the cost perceived by individual travelers begins to rise and is higher than the costs under free flowing conditions. This average cost curve turns back at very high traffic flows, when some travelers decide not to drive due to congestion, delays, and such traffic externalities. The maximum capacity of the road is represented by $Q_{\text{MAX}}$. At any level of congestion, the individually perceived cost is always lower than the marginal social cost, which increases more rapidly with increasing volume. Figure 2-3 shows that for free-flowing traffic between points G and H, the marginal social cost is the same as the average cost.

Socially optimum traffic flow on a road is achieved when the marginal social cost equals the marginal benefit to each traveler, at point D. Thus, ideally, the traffic volume should be limited to $Q_2$. However, since travelers perceive only the lower individual costs, they continue to use the road even as congestion increases. More vehicles keep adding on till the equilibrium point E, where individual costs equal marginal benefit. Volume on the road then increases to the sub-optimal level, $Q_1$.

A congestion charge can help resolve the problem of travelers perceiving road usage costs to be lower than they actually are. If users were charged a toll equal to the distance
DF as congestion costs, then they would perceive and pay a higher cost, at point D. The road would thus, only be used up to a volume \( Q_2 \) as some people would be priced out. The reduction in trips resulting from the toll would equal \( (Q_1 - Q_2) \). These people would end up worse off than before the toll, yet overall social benefit would be maximized.

The strong economic argument for congestion pricing is that a significant portion of the cost of congestion is captured as toll revenues. The revenues would equal the area of rectangle ABDF. In economic terms, the lost consumer surplus (or mobility of people deciding to not drive on the road) is much less than the revenues generated from the congestion charge in the case shown. The revenues can be used in investments to compensate the people made worse off, for example, in enhancing public transportation.

### 3.3. Politics Associated with Congestion Pricing

William Vickrey, who won the Nobel Prize in Economics in 1996 for his ideas on congestion pricing in transportation, has said, “*Even where change is obviously called for, it tends to come in homeopathic doses and to follow lines of proportional adjustment along traditional patterns rather than break into innovative territory.*”\(^{39}\) It is most likely politics that are responsible for this.

In his essay titled ‘The Political Context of Transportation Policy’, Wachs has said that congestion pricing is a good idea and has already been proven to work. He says that the concept is readily accepted in other contexts, such as telephone companies charging differentially for calls based on the time and day of the week, airline fares that are priced according to the timing and location of trips, ‘early bird specials’ in stores and restaurants, and matinee discounts in movie theaters. Planners and transportation economists agree that congestion pricing would have many benefits. Still, the political realities of implementation are so difficult that the policy is rarely adopted\(^{40}\).

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\(^{39}\) Vickrey (1992)

Congestion pricing forces governments to change the way they think about infrastructure costs by considering the social costs not previously accounted for, and making road users pay for these costs. This usually seems more difficult to achieve than a policy like raising the fuel tax by a few cents. A small increase in the fuel tax would be a marginal change, and the people supporting the policy would be far more in number than those who would be affected enough to oppose it. People are used to paying for the fuel they use. Whereas, it would be far more difficult to raise consensus for congestion pricing, in order that it may successfully pass through the various levels of decision-making. One of the reasons for this is the lack of an obvious constituency of supporters for the policy, who would lobby for it at various levels of government.

There is not enough dedicated support for the policy in groups other than scholars of transportation, economics, geography and planning, who form a weak political force. Downtown businesses might gain from reduced congestion but would be apprehensive in their support because they might also lose business to other commercial areas. Freight and trucking industries usually see a congestion charge only as an additional cost, in spite of the fact that they might improve their operational efficiency due to reduced congestion\footnote{Hanson (1995). p.283.}. Transit agencies could benefit from congestion pricing as it would result in increased ridership, but the constituency of transit riders is not powerful enough, as compared to automobile owners or say, colectivo owners in Mexico City. Colectivo and taxi drivers would oppose the increase in operating costs and their riders would fear the additional cost being reflected in increased fares. The constituency of colectivo riders and operators is especially powerful in case of Mexico City because colectivos carry over half the mode share of all trips.

Another reason why support for congestion pricing is low is that paying for congestion relief is not considered a tangible objective for most people. Automobile owners argue that they have already paid for road infrastructure through various taxes. In addition, they pay for using the roads through fuel taxes that are roughly proportional to the amount people drive. Thus, a congestion charge is only regarded as paying twice for the
same roads. Economists know that peak period pricing will cause travel patterns to shift and is a viable policy option, as seen in other industries. However, it is difficult to communicate the idea to laypersons or political leaders because demand for peak period travel is assumed to be inelastic, given the largely homogeneous and rigid work schedules of most people. Since people have to travel at peak hours, it is believed that congestion pricing will have little effect. It will merely raise more money from beleaguered motorists who will still be driving under congested conditions\textsuperscript{42}.

The few examples of implemented schemes around the world, such as in Singapore and London show that prices can be set at an appropriate level to reduce congestion, but how the price is set is critical. Even in the event that a pricing policy is implemented, if the stipulated charge is too high for people to use the roads, then it would be termed a failure in the political arena, the same consequence if the price is fixed too low to reduce congestion. Since these outcomes cannot accurately be predicted beforehand, the potential risks drive politicians away from considering the policy.

The political dilemma also results from the fact that public views and professional views towards congestion pricing are very different, especially in cities where high quality public transport options are limited. In cities where the policy has been implemented with some success, the varying views converged in the manner shown in Figure 3-4. This has been possible only with good and extensive public communication by the professionals and the implementing agency.

The perspective that congestion revenues can be used for public benefit is one that needs to be effectively communicated to the people. While the revenues generated by congestion charging can have any use, in the few cases where the scheme has been implemented, the authorities have pledged to devote the funds exclusively to transportation infrastructure. Public opinion is less hostile to a new charge when the revenue is used to invest in the activities that are taxed\textsuperscript{43}. Due to the reinvestment of

\textsuperscript{42} Hanson (1995). p.283.
revenues in transportation, some people describe congestion pricing not as the commonly understood 'demand restraint' measure, but rather as a 'supply restructuring' measure\(^\text{44}\). The term 'demand restraint' has negative connotations of restricting mobility, and when the policy is communicated as such, it is likely to have a detrimental effect on public opinion and political will. Whereas, restructuring supply in order that high-density public transport modes that are used by more people, receive a mobility advantage over low-density private modes, is a more positive way of communicating the idea to people.

**FIGURE 3-4  Convergence of Public and Professional (Government) Views Required for Successful Implementation of a Road Pricing Scheme**

Source: Adapted from conference presentation by Cain, A. and A. Macaulay\(^\text{45}\)

\(^{44}\) Attributed to Fred Salvucci, Senior Lecturer at MIT
In Mexico City, the transport sector is heavily subsidized. The Metro has a very low fare of $0.20 per trip and is subsidized for about 37% of its operations; however, automobile use is subsidized far more. Subsidies to public transport are subject to public accountability, while the subsidies and externality costs of automobile use are hidden from such accountability because their amount and distribution are simply not quantified. Some of the ways in which automobile use in a city is subsidized include the uncompensated delays on police and emergency vehicles, the costs of pollution and congestion, and the loss of property taxes on land cleared for highways\textsuperscript{46}.

Promotion of the automobile and concerns for network efficiency have led to infrastructure investments in Mexico City that disregard the most economically disadvantaged classes, and cater to the car-owning population. The market has thus responded in a way that people prefer point-to-point colectivo rides to metro or bus transport. The colectivo services, provided by private operators, cause congestion in the central city areas, and contribute to the suburbanization of employment. The development of low-density suburban employment centers, coupled with investment in road capacity to improve access to them, has increased demand for the private automobile further. The higher congestion caused by private automobiles and colectivos has in turn lowered the level of service for road-based public transport, reducing the demand for it.

Thus, it is very important to promote the ‘right’ mode. The colectivos have the largest mode share in Mexico City today, and it is imperative that their service routes be reorganized to primarily act as feeders to high-density public transport, such as the metro and new bus corridors. Doing this, combined with implementing a congestion charge for automobiles for accessing the central city areas, the revenues of which would be used to further improve bus and metro service, provides a package of measures that could balance out the mode share.


3.4. Different Methods of Pricing Congestion

Pricing is used to influence travel behavior by increasing the perceived cost of automobile travel from the user’s standpoint. It may involve the following methods:

(i) direct user charges, in the form of tolls for access to facilities or areas, charges based on trip length, and those based on trip timing (peak or off-peak hours),

(ii) indirect user charges, such as vehicle purchase and registration fees, licensing fees, fuel taxes, and surcharges on parking,

(iii) tax exemptions designed to eliminate inequities, or incentives provided to encourage specific travel modes.\(^{47}\)

Direct user charges increase the cost per trip or the cost per kilometer, causing reduction in the number of trips as well as trip lengths. They may induce increased use of public transit by erstwhile automobile users, with a net reduction in vehicle-kilometers traveled by private low-density vehicles. Indirect charges such as fuel taxes could have similar effects, and in addition, affect the types of automobiles people purchase in terms of fuel efficiency. Whether direct or indirect, the increased cost of using an automobile will influence the location decisions of households and firms, thus affecting land use patterns in the longer term. Reduction in vehicle-kilometers driven is also likely to reduce automobile emissions at a more regional level in the longer term.

The mechanisms for instituting direct charges for the purpose of reducing congestion fall in the category of congestion pricing, or what is also called value pricing. Around the world, the policy has been applied to usage of private automobiles in the following distinct ways, each with its own merits and demerits. These applications of congestion pricing vary in their technological sophistication, costs, scale, and consequences, and fulfill different objectives.

1) **Cordon pricing, and area-based pricing**: Schemes of this type involve pricing a designated area that suffers from congestion, with travelers paying for driving their automobiles into the area. It is usually the central business district of a city that becomes part of a ‘congestion zone’ due to the high number of trips made there. Travelers pay for crossing a cordon while entering or exiting the zone, or for driving

\(^{47}\) Soberman and Miller (1999)
within the zone. This form of congestion pricing first began in Singapore as an Area Licensing Scheme, and was recently implemented in London. The charge can be collected from drivers each time they enter or exit the zone. It is collected as a daily fee that does not restrict the number of trips made to the congestion zone during stipulated hours, as in London.

2) **Facility pricing, or time-based pricing of individual streets or highway lanes:** This involves electronic collection of charges from travelers on a congested street or highway during peak hours. People in vehicles having high occupancy, in low-emissions vehicles, transit vehicles, or other target categories are discounted or waived of the charge. Such schemes have mostly been implemented on freeways in the United States and Canada.

3) **Distance-based pricing:** This is a sophisticated form of pricing based on the distance driven on particular facilities, in certain areas, or during certain hours on the transportation network. There are few examples since the technology is still being developed. Germany has instituted distance-based charging for heavy goods vehicles, with other European cities also considering the approach.

4) **Electronic Road Pricing (ERP):** This is a form of pricing where the daily operations are not manual, but are managed through intelligent transportation systems (ITS) with automated charge collection. ERP is considered a more accurate form of pricing because the charges paid by travelers can be programmed to vary with traffic conditions, location, and time of day. There is a wide spectrum of technological choices that have been used to implement ERP, though most are still new and relatively expensive. All examples of this form of road pricing have been executed in cities of the developed world, such as Toronto, San Diego, Melbourne, Trondheim, (Norway), and Singapore. One reason for this is the high technology cost and another, possibly more significant reason, is the presence of accurate vehicle registration databases in these cities. The absence of a single current vehicle database in many developing cities makes the option of ERP almost impossible. Indeed, the operation of any congestion pricing scheme, whether electronic or not, will necessarily depend on reliable registration records for all categories of vehicles.
In some cases indirect user charges are preferred over direct charges as a means of managing travel demand. These charges, such as fuel taxes, vehicle registration fees, and parking charges, are often suggested to discourage use of the automobile because they increase the total cost of driving, and also because they are considered easier to implement. However, they are not considered in the realm of congestion pricing because they are not based on location or time of travel. These charges do not lead to targeted improvement in congested areas, and because they are more broad-based, only small increments are politically feasible. The small changes typically do not result in very noticeable changes in travel habits. Parking surcharges applied in congested central business areas can be considered closest to congestion pricing. This is especially the case in places like Mexico City where on street parking in such areas is either heavily employer-subsidized or free.

Parking charges have been introduced in cities around the world as a first step towards more sophisticated urban road pricing schemes. Not only are they relatively easier to implement but they also help in creating awareness and acceptance among users regarding the cost of on street parking and driving in central city areas. Parking charges can be used as a proxy for congestion pricing to start with, by being differentiated according to different criteria. Parking charges can be (i) higher in central business districts and zones of high traffic, (ii) higher during peak hours to discourage long-term parking, (iii) higher on weekdays, to distinguish commuter parking from weekday traveler parking, and (iv) higher for long-term parking, to provide incentives that encourage short-term parking. The revenues can be used for local investment. For example, in Quito, Ecuador, where parking was previously unregulated, new parking charges imposed in the city center are used to fund the city’s Bus Rapid Transit System⁴⁸.

Economic instruments such as pricing can also be used as incentives to encourage certain travel modes, such as fare reductions on public transit. However, this necessitates that a robust and efficient public transit system be in place first. For example, in London, before the congestion pricing scheme was introduced, in addition to increasing the size of the

⁴⁸ Breithaupt (2004)
bus fleet, the bus fares were artificially kept low to make transit use more attractive than driving a car. However, where mass transit is predominantly under private control, such as in case of the colectivos in Mexico City, this policy is very difficult to implement.

3.5. Brief Overview of Congestion Pricing Schemes Around the World

In this section, we extend the theoretical overview by describing some varied cases of congestion pricing implemented in cities around the world. We have paid particular attention to the schemes implemented in London and Singapore, since in both cases, the scale of the scheme is large enough, and the number of trips to the city center is high, as is the case in Mexico City. These schemes are both area-based and surrounded by a ring road, though very different in pricing structure and technology.

3.5.1. London Congestion Charging Scheme

The London Congestion Charging Scheme is regarded as the world’s largest congestion charging operation. The objective of the London Congestion Charge was to encourage people to use public transport, bicycles or walk, instead of driving into Central London. It aimed to increase efficiency, speed and reliability of public and private transport journeys and to raise revenues to re-invest in transport improvements. The scheme in London also apparently helped reduce pollution in the central areas by encouraging use of clean fuel vehicles, as owners of such vehicles were exempt from the charge. However, may argue that policies to reduce air pollution and policies to reduce congestion must be kept separate because driving a clean fuel vehicle still adds to congestion. In addition, the area of the London scheme is considered too small to facilitate significant reduction in regional air pollution.

The 21-sq. km. congestion charging zone is bounded by the London Inner Ring Road and about 200,000 vehicles drive into it per hour in the morning peak. It requires motorists to pay a daily charge of £5 for entering the charging zone between 7.00am and 6.30pm each weekday, excluding holidays.

49 Mahendra (2003) - Case Study on London Congestion Charging Scheme completed by the author for European Local Transport Information Service
Drivers pay to have their vehicle number plate registered on a database. About 230 CCTV cameras installed along the boundary and inside the zone record images of vehicles entering, exiting and moving within it. An Automatic Number Plate Recognition (ANPR) system matches vehicles with the database of registrations to charge drivers who have not paid. Payment can be made weekly, monthly or annually through various modes and outlets. Motorcycles, taxis, emergency and alternative fuel vehicles are exempted and the 136,000 residents of the charging zone receive a 90% discount. Non-payment leads to different levels of penalties, followed by vehicle clamping or removal if drivers continue to default.

Preceding implementation, TfL added over 300 buses representing 20% more passenger spaces and improved services to accommodate new riders, since 85% of people enter central London using public transport. The revenues raised must by law, be spent on transport improvements in London for the next 10 years. However, initial public aversion to the scheme and protests by freight transport operators were obstacles, along with insufficient enforcement affecting the scheme's credibility. TfL expected the scheme to cut traffic levels by 10-15%, but the traffic reduction has been much larger than expected, at about 30%, leading to unexpectedly lower revenues. In addition, there have been complaints about loss of retail business in the city center; however, some attribute this impact to a slower economy and lower number of tourists visiting London in 2003.

Effective public information regarding importance of the charge and payment procedures, extensive stakeholder consultations, and public hearings have been key factors for the scheme's success. Other important factors were enhancement of bus services before implementation, and accompanying measures to improve traffic management. The scheme is just one measure of an overall strategy for improving transport in London.

3.5.2. The Area Licensing Scheme and Electronic Road Pricing in Singapore

Singapore introduced the world’s first urban road pricing scheme in 1975 as an Area Licensing Scheme. The Land Transport Authority (LTA) in Singapore has been actively trying to curb road congestion and to encourage use of public transport, given the limited
land space in this small island country. Two means have been used to do this – one, controls on car ownership through vehicle purchase quotas, and two, restraining vehicle usage through road user fees. High gas taxes further add to the costs of driving. At the same time, the LTA has developed a good public transport network comprising buses, light rail and mass rapid transit under a regulation that no residence should be more than 400 m away from a public transit stop.

Under the Area Licensing Scheme, the central business district (CBD) of Singapore was cordoned as a Restricted Zone covering 7.2-sq. km. and commuters had to purchase a paper-based Area License to drive their cars into the CBD during peak hours. There were exemptions for cars with more than four people, and enforcement was manual with police checks at the entry cordons. Results in 1992 showed that traffic entering the CBD in the morning peak was about half the level before the scheme was introduced 17 years earlier. Speeds had increased by 20% and accidents had fallen by 25%. Public transport’s share for working trips increased from 33% in 1974 to 67% in 1992. The fee was a flat charge of S$3 first applied only in peak hours, but then modified to include the whole day on week days.

Some adverse impacts of this scheme were that it increased congestion on the expressways and feeder roads leading to the CBD. To deal with this, the government introduced manually operated congestion tolls on the three main expressways leading to the CBD. However, together these schemes, caused underutilization of roads in the CBD and immediate congestion just outside it. In addition, the manual operations made future modifications inflexible.

Therefore, in 1998, the LTA implemented the Electronic Road Pricing Scheme (ERP) that covers the same cordon area as before, and comprises a 2.54 GHz dedicated short-range radio communication system consisting of an In-vehicle Unit (IU), ERP gantries, and a control center. The 29 gantries installed at the cordon entry points automatically

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deduct charges per crossing from pre-paid smart cards via an In-Vehicle Unit inside each automobile. Drivers can add credit to the smart cards, and charges are based on type of vehicle, location of crossing, day and time of day. Traffic speeds are reviewed quarterly, and the ERP rates are adjusted to maintain average expressway traffic speeds of 45-65 km/hr and speeds of 20-30 km/hr on roads inside the CBD52.

The result was that the volume of traffic entering into the CBD fell by 10-15% compared to the old Area Licensing Scheme. The substantial drop in demand resulted from the charge being per crossing rather than per day. This led to lower revenues than in the days of the earlier scheme because the increased number of payments did not offset the reduction in traffic volume. However, the revenues from the Singapore congestion pricing schemes have been used to develop the Mass Rapid Transit (MRT) and light rail network in Singapore. This has increased the modal split of public transport from 46% in 1976 to 70% in 1991 for all journey-to-work trips to the CBD53. For vehicles not possessing an IU, smart card, or sufficient funds, a digital image of the license plate is recorded to enforce violation penalties.

In both cases, London and Singapore, the objective of the government was to reduce congestion, and the revenues are being used to improve public transport. As an economic instrument to charge car drivers the marginal social costs, the Singapore scheme is more technologically sophisticated as it charges based on congestion levels, location, and time of day, whereas London uses a simple camera-based technology to charge a daily flat fee.

### 3.5.3. Congestion Pricing Initiatives in Asia, Europe, and North America

Other schemes round the world have been implemented to serve different objectives, and with mixed results. For example, in Hong Kong, feasibility studies have been done to develop an ERP proposal similar to Singapore for reducing inner city congestion. Although successful technology trials have been completed in 1998, there is no

government support for the scheme. This is in spite of the fact that Hong Kong has a well-developed mass transit network as an alternative to driving.

Public opposition is strong towards payment of charges, and because of privacy concerns about being constantly monitored on the road. In addition, on the government side, there is a fear of failure because in 1982, fiscal controls were adopted in Hong Kong to curb traffic, though these were not in the form of congestion pricing. The measures included increasing the annual fee for private cars by three times and doubling the fuel tax and the registration fee for new cars. The high costs resulted in about 20% reduction in vehicle ownership between 1981 and 1984, but congestion levels reduced only in the least congested areas, while remaining unabated in the most congested areas. The public perception was that the congestion problem had been exaggerated in 1982. The failure has led to stiff public and political opposition to any new schemes considered.

Governments in Kuala Lumpur and Bangkok have also rejected congestion pricing proposals for political reasons, although both cities routinely implement road tolls for infrastructure financing. On the other hand, cities in Norway, including Bergen, Trondheim and Oslo, have pursued cordon-based urban road pricing since 1986 as a means of financing roads, but are now planning to modify them to become congestion charging schemes. Since the objective of the ‘toll rings’, as they are called in Norway, has so far been only to raise revenues, the tolls have been low. They have only led to small traffic reductions, around 6-7% for Bergen, 3-4% in Oslo, and 10% in Trondheim, during the charged periods54.

In Europe, the European Commission has been espousing road and congestion pricing for internalizing the external costs of transport for many years55, with the result that many cities are considering congestion pricing proposals in different forms. After the success of schemes in London and Durham in the United Kingdom, Edinburgh has proposed its own congestion charge with inner and outer cordons around the downtown area. Other cities

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in Europe are proposing to introduce a kilometer-based electronic charging scheme as a more accurate form of congestion charging. In the Randstad region of the Netherlands (including Amsterdam, Rotterdam, The Hague, and Utrecht), a congestion charging scheme with multiple cordons was proposed in the late 1980s but was not implemented due to public opposition. Now, a kilometer-based charge is being considered for the region. In Germany, electronic distance-based charges have already been implemented on major motorways for heavy goods vehicles because freight traffic in the country is growing very rapidly since the formation of the European Union.

In North America, much of the traffic congestion occurs on the freeways that are peripheral to downtown urban areas, linking several cities that are part of a larger metropolitan region. Thus, congestion pricing in many parts of the United States has been implemented either on an entire highway facility, or in the form of tolls on dedicated highway lanes to speed up traffic during peak hours. These lanes, usually called High Occupancy Toll (HOT) lanes, allow vehicles with higher occupancy to travel free or at a discount, while those with lower or single occupancy pay a charge. Average traffic speeds on these lanes are usually higher because most commuters prefer to drive on the congested un-tolled lanes. Highway pricing projects with time-based charges are found in Lee County, Florida, Toronto, and New York, while HOT lanes are being operated in Houston, Minnesota, and San Diego, California.

In Texas, the concept of HOT lanes is being taken a step further by using the toll revenues to implement high frequency express bus services (Bus Rapid Transit) on the ‘managed lanes’, as they are called. The Federal Transit Administration and Federal Highway Administration have been promoting congestion pricing in the United States since the early nineties but few states were willing to implement it due to political concerns. Now, however, after observing the success of the London scheme, several HOT lane projects are being planned in different parts of the country. The following section describes the equity arguments that make congestion pricing a contentious policy.
3.6. Equity Issues with Congestion Pricing

While pricing is a viable economic instrument to provide choices and manage demand, it causes different impacts for different classes of society. This is a challenge because it underscores the social inequality especially prevalent in fast growing cities of the developing world.

Perhaps the most important political danger with congestion pricing is an inadequate resolution of the equity issue. It is obvious that for congestion pricing to be successful, there would be an involuntary change in travel patterns for some people. Those who oppose the policy argue that the people who would be made worse off than they were before, would disproportionately consist of lower income people and workers with inflexible work schedules, and in case of Mexico City, a large proportion of street vendors whose only means of transporting their merchandise is their private vehicles.

There are valid means of addressing this issue, such as redistributing the revenues for public transit improvements, as has been done in London, providing discounts on the congestion charge, tax credits to the poor, reductions in property taxes, and other exemptions based on household income and level of expenditure. However, when corruption in the government is considered high, as in case of Mexico City, citizens perceive only the immediate negative impacts, with little hope that the revenues will be used judiciously to redress the inequities. It has been argued that existing methods to fund transportation investments such as property taxes and sales taxes are more regressive and if these were replaced by congestion charges, then in principle, transportation finance would become much more equitable than it is today\textsuperscript{56}.

The intent behind congestion pricing is that the increased price of travel will encourage people who can do so to alter their travel behavior in any of a number of ways. This could be to take an alternate route that is less crowded, to take public transit, join a car pool, or to shift one’s travel time to another when the roads are less crowded. Some travelers may change the origins and destinations of their trips, or forego less important

\textsuperscript{56} Wachs (1995)
trips, due to the increased cost of congestion they would have to bear. The resulting change will of course, depend upon the particular features of the policy.

The very fact that congestion pricing is about using a market-based theory for a public good, that is, about charging people to change their behavior makes it appear coercive and restraining, especially to the lower income classes of people. In that sense, some consider it to be an elitist measure, as it does not take into account different sub-groups of the typical urban population. This has become a prominent environmental justice issue; however, others argue that it congestion pricing is a better policy than displacing households by building highways through communities. Given these arguments, an important political component of the decision to implement a pricing scheme is to understand the distribution of winners and losers. Table 3-1 shows the direct groups of winners and losers that would result from implementation of congestion pricing. It becomes politically difficult to implement because invariably, the number of direct losers is larger than the number of direct winners.

**Table 3-1  Congestion Pricing: Winners and Losers**

<table>
<thead>
<tr>
<th>Direct Winners</th>
<th>Direct Losers</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Wealthier motorists who value their travel time savings more than the charge costs.</td>
<td>▪ Lower income motorists who pay the charge because they have no travel alternative, but don't value their time savings more than the charge costs.</td>
</tr>
<tr>
<td>▪ Bus and rideshare travelers who enjoy improved service due to reduced congestion and economies of scale.</td>
<td>▪ Motorists who have to shift to other routes to avoid the charge.</td>
</tr>
<tr>
<td>▪ Recipients of congestion charge revenues or incentives.</td>
<td>▪ Users of roads that are not charged, or immediately surrounding the congestion zone, who experience increased congestion.</td>
</tr>
<tr>
<td></td>
<td>▪ Motorists who forego trips due to the charge.</td>
</tr>
<tr>
<td></td>
<td>▪ Motorists who shift to transit and rideshare modes due to the charge (although service improvements due to economies of scale may make some of these net winners).</td>
</tr>
</tbody>
</table>

*Source: Victoria Transport Policy Institute*\(^{57}\)

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Congestion pricing also does not necessarily represent a ‘fixed’ approach because after it
is introduced with certain parameters, a subsequent local government may raise or lower
charges at will, or abolish or reinstate the charge, for political reasons. On the other
hand, when physical restraints such as pedestrian streets or bus lanes are used to manage
urban traffic, they are likely to be more permanent. The idea of using these approaches
together with pricing can work because their goals are similar.

Given the fact that road pricing will affect people living in the DF, the EM, and even the
states surrounding the MCMA, the success of the scheme will depend on enforcement by
each jurisdiction, and how the revenues are split between them. The intraregional
competition between multiple jurisdictions may undermine cooperation and coordination
efforts, as each authority will seek its own fair share. This is highly possible in case of
the MCMA. Since the DF has the comparative advantage of dense metro services as an
alternative to car use, the revenues from a congestion charge could be used to invest in
metro extensions to the EM, a constant demand of the EM residents. However, the bone
of contention is that the EM government is not willing to support the DF authority with
investment funds for the metro as it receives no share of the fare revenues.

By charging a congestion fee from car users, the transportation authority of the DF
(SETRAVI) can help “restructure supply” in favor of public transport by eliminating the
hidden subsidies on private automobile users. Politically, the proposal to use congestion
pricing revenues for extending the metro into the EM, and improving service, would be
very favorable, as the metro is far cheaper than the colectivos. The colectivos, on the
other hand, could be offered discounts with a reorganization of service routes and
creation of special lanes, in return for not raising their fares. Effective public
communication of the costs and benefits of a congestion charge to different stakeholders
is essential to gain support for these ideas.

In the next chapter, we present a detailed discussion of the applicability of congestion
pricing in the context of Mexico City.

58 Hodge (1995)
59 Use of this term to describe congestion pricing is more publicly acceptable than “demand restraint”, and
is attributed to Fred Salvucci at MIT
CHAPTER 4. APPLYING THE IDEA TO MEXICO CITY

4.1. Private Travel in the MCMA

The private automobile offers desired convenience and status to the relatively higher income households in Mexico City. However, few people consider the total costs of operating an automobile. Ownership taxes (such as the tenencia in Mexico City), depreciation, licensing and insurance costs are regarded as sunk costs. The variable costs of using an automobile remain relatively low and unless they are constrained by congestion costs, parking costs, scarcity of gasoline or another additional externality cost, rising personal wealth will continue to increase the motorization rate. As cars take on more of the city’s mode share of trips, metro trips have continued to decline. While there are many other reasons for inefficiency of public transit, an obvious disadvantage is the implicit subsidy that is provided to private travel at the cost of improving public transit. While the level of concern over transit subsidies is always high, seldom is any thought given to the large collective subsidy that automobile travel enjoys.

There is a significant perception that demand for private transport in Mexico City is so inelastic that only extreme pricing measures would work to change travel behavior, and these would not be politically feasible. The reason for the inelasticity is the rapid decentralization of the city, compounded by limited availability of public transport options in areas far from employment centers. Recognizing that congestion pricing is a drastic measure but the time may be right for it in Mexico City, in this thesis we attempt to understand whether this perception is true. It is important to bear in mind that any form of congestion pricing is best implemented through stakeholder participation, and along with other policy measures that may include regulations for the colectivos, coordination between the bus and metro systems, and increased parking charges in congested areas.
4.2. History of Transport Policies Responsible for Growth in Automobile Trips in the MCMA

The number of vehicle kilometers traveled (VKT) in Mexico City has increased over the last two decades. This is partly due to a trend of policies and circumstances that have directly or indirectly led to a growth in vehicle trips. The mode share of the minibuses or colectivos increased rapidly from 5.5% to 58.6% between 1986 and 1998\textsuperscript{60}. In this period, the DF and EM governments had both given out subsidized loans to private colectivo operators for modernizing their fleets, replacing the traditional five-passenger pesero with the higher capacity colectivo, and switching to unleaded gasoline. In addition, the performance of the publicly owned bus company Ruta 100 declined due to lack of funds, poor management, competition from the colectivos, and decaying institutional capacity. Thus, with this support to private operations, the colectivos soon grew in number as they provided the only flexible means of public transport between the downtown areas and the suburbs.

In the period 1988 to 1997, colectivo ridership in Mexico City grew from about 6.3 million trips per day to 15 million\textsuperscript{61}. The operators face limited regulation once given permits, and usually fix their own fares on the routes they operate. Colectivo fares in the DF are about 30% to 130% higher than fares on the publicly operated metro, trolley bus and bus services, while in the EM, fares go up to 430%\textsuperscript{62}. This is highly inequitable since most low-income households are located in the EM municipalities, distant from the city center and with limited metro or bus access. The colectivos contribute to a significant amount of traffic congestion in central city areas, as they idle at stops, competing with each other and waiting for passengers. 95% of the colectivo vehicles are now about 8 years and older, thus they not only contribute to central city congestion but also to emissions in a significant way.

\textsuperscript{60} COMETRAVI, v.7 (1999)
\textsuperscript{61} Villegas-Lopez (2000)
\textsuperscript{62} Ibid.
The private colectivo operators are organized into powerful cartels wielding immense political power and they have been pushing for fare increases for a long time. In areas where the metro does not provide access, the colectivos provide an important feeder service. However, in other areas their routes compete with those of the metro, and people often use the colectivos instead of the metro if it will reduce the number of transfers they need to make. According to a survey completed in 1997, colectivo operation generates an average of 100,000 direct jobs, with each unit having an average daily ridership of 688 passengers. The colectivo operators therefore represent a powerful stakeholder group that will be vocal against a congestion pricing policy, unless they see advantages for themselves.

With support from the government, the number of taxis has also grown in recent years like the colectivos, though to a lesser extent. To regain political support for the official party, the DF government increased the number of taxi permits from 20,000 to 80,000 between 1988 to 1992. After the formal issuing of permits ended in 1992, an estimated 10-12,000 ‘pirate’ taxis began to operate illegally with forged papers. A majority of these do not operate from a designated taxi stand, but rather often drive around empty looking for passengers, and adding to congestion levels. Today, the DF has 106,000 taxis, with an additional 19,000 pirate taxis, according to a recent study. The study says that the DF may possibly have the highest supply of taxis in the world, with a taxi in the DF running vacant between one-third and one-fourth of the time. Insecurity concerns about the pirate taxis are high, and local residents consider it quite unsafe to hail an empty pirate taxi from the street. In recent times, there have been efforts by the Public Security and Transportation authorities in Mexico City to remove pirate taxis from circulation, and so far approximately 7,000 pirate taxis have been removed.

The chief reasons for the growth in the number of colectivos and taxis are the inaccessibility of the metro in areas outside the DF, and the decline of the urban bus company Ruta-100. The DF bus services were brought under public control from their

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63 Connolly (2000)
64 Navarro (2003)
private origins in the early 1980s. However, high subsidies and political conflicts led to their re-privatization in 1996\(^{66}\). The new companies operating the buses have been largely unsuccessful in attracting ridership, and this is why the DF authorities are now planning new Bus Rapid Transit corridors in the city.

Overall ridership on the metro service too has declined in recent years. Some reasons for this are the rapid increase in car ownership and use, the increase in colectivos and the shift in population from central city areas to the EM, where the metro has mostly been inaccessible. Mexico City’s metro service is the cheapest in the world with a per trip cost of US$ 0.20, and ranks first in terms of average number of passengers per kilometer; yet it is heavily subsidized. Since 1989, in spite of 37 extra kilometers being added to the metro network, its ridership fell from a peak of 4.7 passengers per day to about 4.0 million in 1999. The fact that out of eight lines, the three oldest lines carry about 60% of all metro passengers suggests a major imbalance in the metro network. The metro and Ruta-100 bus services used to be integrated to some extent through the Metrocard. However, with the demise of the Ruta-100 services, the Metrocard was abolished in 1997, making travel on public transport costlier for passengers. It is only recently that the DF government has proposed plans for expanding metro services in the northwest and northeast, to serve these corridors with high demand; however, there is not yet any agreement between the DF and EM governments regarding financing of the extensions.

Given the problems with institutions, operations and negative perception of public transport, transportation policy in Mexico City in recent decades has focused on building more roads to fulfill growing traffic demand. In doing this, the distribution of resources between the EF and the DM has been very disparate leading to a conflict of interests between both governments, while contributing to increased decentralization of the city. Beginning in the 1970s when the first ring road (Circuito Interior) was constructed, followed by the creation of high capacity roads called the ‘ejes viales’ through downtown Mexico City in 1979-80, and finally the completion of the Periferico, a beltway around the DF in the early nineties, the government has been attempting to alleviate congestion

\(^{66}\) Connolly (1999)
through increasing infrastructure capacity. Many of these roads are already very congested today, and the Periferico has been described as “a parking lot for much of the day” according to a 1998 article in The Economist\(^\text{67}\). According to SETRAVI (1999), a third ring road is now being built with the northern half constructed as a toll highway while the southern half is still under construction\(^\text{68}\).

Grade separations in the form of flyovers have been introduced to improve flow on important routes, with new highways being built in the north (Cuautitlan-Tlanepantla), northwest (La Venta-Lecheria, a tolled highway) and the east. Since these roads bring congestion relief in the short term, their construction is considered a popular measure. The current administration under Mayor Lopez Obrador, has begun construction of elevated second levels (Segundos Pisos) over the existing Periferico ring road and another road called the Viaducto in the city, amidst immense controversy and with high costs. The first phase of this project cost US$ 80 million, while the second phase is expected to require an investment of US$ 200 million\(^\text{69}\).

This thrust of transport policy has often been called the “black-hole theory” of infrastructure investment\(^\text{70}\). Increased road investments reduce congestion and travel times in the short term, altering travel patterns by making travel easier, but they also increase average trip lengths and number of trips. In due course, the new capacity falls short for the demand induced due to improved travel conditions, congestion begins to rise again, and there is need for further road investments. The phenomenon is likened to a black hole because in spite of heavy investments, it ultimately has no impact on reducing congestion. While it can be argued that building more roads generates jobs, and provides increased access, these benefits are outweighed by the resultant costs of increased sprawl in an already very decentralized city. For example, the COMETRAVI study (1999) mentions how after a new toll highway in the northwestern part of the MCMA was

\(^{67}\) Survey. “Commuting – All Jammed Up”, \textit{The Economist}, September 3, 1998

\(^{68}\) Gakenheimer and Zegras (2003)


\(^{70}\) Hanson (1995). p. 439
completed, it led to new residential, industrial and service developments that generated increased trips in the area\(^{71}\).

The long distances also make metro extensions very costly. This is one of the reasons for the limited reach of the metro network in Mexico City, compounded by the lack of cooperation between the DF and EM governments. In addition, road connections between the DF and the EM are not designed as part of a system, and have missing links\(^{72}\). So while new investments are being made to relieve congestion, there is in fact a greater need to improve accessibility for EM residents by filling the gaps in the network.

There has also been no actual implementation of regulation to manage the increasing number of colectivos, and only limited expansion of metro service, thus making private automobiles the only viable option supported by the government policy of increasing road capacity. A new metro line (Metro Line B) running between the downtown and the EM, that opened only in the year 2000, has had good ridership up to now and eliminated some colectivo trips. Another positive development is the approval of two bus rapid transit corridors on the Eje 8 Sur road and the Insurgentes Avenue, two major demand corridors in the city. These are currently under construction, and their total budget is US$ 20 million, in contrast with the US$ 80 million spent in only the first phase of the Segundo Piso construction.

Another factor that has led to increasing road congestion in the city is the free on-street parking in most congested parts. The 1994 Origin-Destination Survey showed that the highest percentage of the city’s on street free parking is in the DF, comprising one half to one third of total parking in the area. Free parking contributes to congestion, and does not generate any revenue. In addition, the areas that suffer from most congestion are also the centers of business and employment, and most employers in Mexico City provide free parking. Parking meters with a charge of US$ 0.20 for 15 minutes have recently been installed in some districts such as Zona Rosa. However, since Zona Rosa is an affluent

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\(^{71}\) COMETRAVI, v. 1 (1999).

\(^{72}\) Gakenheimer and Zebras (2003)
district and provides mostly high-end retail and shopping, the introduction of parking meters has not made a significant difference in traffic. In the Centro Historico district for example, parking lots in areas such as Bellas Artes are constantly full, even at the price of 24 pesos per hour (US$ 2.40). The price range in other lots in the Centro Historico ranges between 12 and 16 pesos (US$ 1.20-1.40)\(^73\). Due to the presence of ample free parking, either employer-paid or on-street, these lots barely manage to cover their costs. This also shows that most Mexicans who own and use cars have low sensitivity to parking prices, once they have already invested in an automobile. In other delegaciones of the DF, parking meters have faced stiff opposition when proposed, and thus were never implemented.

4.3. Description of Prior Regulatory Attempts

The Hoy No Circula program, started in Mexico City in November 1989, was a form of restraining car use to reduce air pollution, not to manage congestion. The program prohibits car use by individual motorists for one day of the working week, based on the car’s registration number. Non-compliance with the ban leads to a fine. The main rationale of the program was that on any working day, there would be 20% fewer cars on the roads, congestion would be reduced, and average traffic speeds would increase.

This measure has had mixed results. It resulted in an increase of older second hand vehicles purchased by lower income households that owned a single car, so that the vehicle could be used on they day they faced the driving restriction. The program actually led to an increase in overall vehicle kilometers traveled because of the second and third cars that people bought in response. Critics say that the Hoy No Circula increases the cost of commuting by private car in an inefficient way. The ban on car use not only leads to a waste in the car’s capital cost, but also does not allow car drivers to trade off the loss in utility in the market\(^74\). The higher cost is only manifested in a loss of productivity of households, as the money is neither invested in pollution control technologies, nor collected by the government for other welfare measures. Thus, the Hoy

\(^{73}\) Reforma, October 6, 2003
\(^{74}\) Villegas-Lopez (2000)
No Circula is considered quite inadequate as a measure to reduce air pollution, though it helps ease congestion to some extent. Recently, there have been proposals to modify the program such that cars older than 1993 are banned on at least two days of the week, newer cars are banned on only one day, and cars manufactured after 1999 face no restrictions.

The problems of traffic congestion and air pollution are, however, becoming so acute in the metropolitan region that since the Hoy No Circula is the only functioning demand restraint measure, it is considered better than nothing. According to recent news, transportation officials in Toluca, capital of the State of Mexico, are considering the application of Hoy No Circula to deal with growing levels of pollution by rationing the use of vehicles.

Another regulatory measure proposed by the Secretariat of the Environment (SMA) of the DF in 2001 was to ban all vehicles from entering the old city center, the Centro Historico. Consultations were held with various stakeholders, after presenting data on potential emissions reductions in the city center if vehicles were to be banned. The proposal however, did not move ahead due to opposition by many groups, including automobile manufacturers and distributors, freight companies and downtown businesses.

Vehicle bans and regulatory measures such as the Hoy No Circula are considered less controversial than congestion pricing because they affect all sections of society equally. There are other similar methods of demand restraint such as raising the fuel tax or raising parking charges. However, these affect all modes of transport and all users for all trips at all times of day, creating high inefficiencies or deadweight losses. A parking charge is usually not applicable for any specific time period or location unless it is implemented as a surcharge for congested zones. An increase in fuel tax does not cause significant change in travel behavior because it is often too small in magnitude and spread over a wide population base. Congestion pricing is a better approach because it can be used to eliminate congestion in a targeted manner through peak hour charges or charges on
certain facilities. In addition, it helps capture the high costs of congestion as toll revenues that can be hypothecated for other public investments and can generate value.

4.4. Arguments for Considering Congestion Pricing in the MCMA

The residents of Mexico City acknowledge that traffic congestion is a serious problem affecting their quality of life, as corroborated by a survey that was conducted as part of this research. In fact, in the wealthier areas where car use is high, the limited availability of parking spaces is a major problem. According to reports in a local newspaper, a new bikeway running through the city’s main Chapultepec Park is being used as a car park by people. Traffic is high because there are many restaurants and museums in the area, and the bikeway, demarcated by red paving, is nearly full with parked cars, relegating bicyclists to the regular streets or sidewalks\(^{75}\).

The reason for the increase in congestion levels in the MCMA is the rapid growth in private automobiles and colectivo traffic. The colectivo system has especially flourished due to the failure of the bus system and lack of expansion of the Metro network in recent years. Since 1960, the low-occupancy gasoline fleet that includes private cars and colectivos has grown by 15.5 times, while the high-occupancy diesel and electric fleet, including buses, has grown by only 7.6 times\(^{76}\). Figure 4-1 shows the change in daily passengers on the major transport modes in the city with a change in GDP over the years.

**FIGURE 4-1** Average Daily Passengers in Mexico City, per mode

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\(^{75}\) *Reforma* - Sunday, October 26, 2003.  
\(^{76}\) Villegas-Lopez (2000)
Low-capacity vehicles such as cars, taxis and *colectivos*, together had about 70% of the trip mode share in 1995. It is this shift in modal share towards lower capacity modes at the expense of bus and metro ridership that is considered the major policy challenge facing the city’s transportation system\(^{77}\).

The growth in low-capacity vehicles has significant impacts on air quality as well. In terms of emissions, 50% of sulfur dioxide, 65% carbon monoxide, 40% of nitrogen oxides, and 60% of volatile organic compounds are released by private vehicles\(^{78}\). In the absence of viable public transport alternatives, the *colectivo* system functions as a privately run public transport system. The *colectivos* are well used because they provide frequent access to most parts of the metropolitan area, unlike the metro and bus services. *Colectivos* have the largest mode share of trips, yet the average fares are about double that of the bus or metro, and are continually increasing, with the most recent increase being in January 2004. Most people have to travel on more than one mode to get to their destinations, usually taking more than one *colectivo*, leading to high public transport costs for the lower and middle-income classes. The *colectivos*, thus offer the advantages of public transport, but with the negative impacts of excessive competition and unregulated growth. Consolidation and reorganization of the private *colectivo* services is essential so that they act as feeders to the higher capacity public transit modes.

Government run public transport receives high subsidies in Mexico City. Subsidies cover 37% of Metro operations and 60% of light rail operations. Current transportation revenues, that include ownership fees, traffic fines, used car sales taxes, and parking fees barely cover one-half of total transport expenditure. More sources of revenue are therefore desirable. The metro is priced extremely low at two pesos per trip, with the fare remaining unchanged for several years. In addition, parking fees received from publicly run lots and parking meters are limited, since very few parts of the city impose parking charges through meters or otherwise. Congestion pricing can therefore be an alternative to explore, since it not only may result in reduction of private vehicle usage but it would

generate additional revenues that can be invested in transportation improvements, as done in the cities of London and Singapore.

The World Bank and the Global Environmental Facility recently approved funding for a project to establish Bus Rapid Transit (BRT) corridors on the city's two major roads, the Insurgentes Avenue and the Eje 8 Sur (Axis 8 – South). This will be an important step towards providing public transport alternatives, and would complement potential implementation of a pricing policy. A key argument for congestion pricing in Mexico City is that automobile trips are highly concentrated. Over 60% of automobile trips occur within a radius of 10 km from the city center, and 80% of overall trips have their origin or destination in the Federal District. According to COMETRAVI (1999), 86% of commerce and services are concentrated in the DF forming over three-quarters the economy of the entire MCMA. This leads to a high volume of commuting from the surrounding State of Mexico into the DF, leading to heavy congestion during peak hours.

While congestion pricing can take different forms, as an Area Licensing Scheme, road toll, peak hour charge, and so on, for area-based congestion pricing schemes such as those in London and Singapore, the concentration of urban travel demand in a particular geographical area is a pre-requisite. In the Mexico City Metropolitan Area (MCMA), in spite of growing decentralization, there is evidence that automobile trips are highly concentrated in the DF. 75 to 80% of the vehicles in the MCMA are registered in the DF (excluding trucks). Of the 69,000 taxis registered in the MCMA, 64,000 are registered in the DF. The major freight terminals are located just on the periphery of the DF, and 29% of the city’s freight originates in the DF79, leading to serious congestion caused by truck traffic especially during peak hours. In addition, the Metro network is confined to the DF and the three most heavily used Metro lines have destinations in the DF. Roughly 21 million vehicle trips are made in the MCMA today, of which, 14 million are made in the DF and 7 million in the EM. By 2020, the total number of trips is expected to increase to 28 million, with 17 million trips made in the DF, and 11 million made in the EM80.

80 Ibid.
This shows that while trips per person in the DF may reduce in future years due to growing decentralization, the absolute number of trips made in the DF will grow. This increase of 21% by the year 2020 is significant, in light of the fact that congestion levels in the DF are already critical. In Mexico City, the Northern and Eastern roads provide the primary access from the suburbs to the DF, and these are the most congested urban highways. Therefore, another alternative could be facility pricing, possibly during peak hours or during other times of day when congestion is at a maximum. However, the only available data, from the 1994 Origin-Destination survey done in the city, shows that only 26% of trips were made with origins in the suburban municipalities and destinations in the DF. Thus the option of facility pricing would not capture the large volume of trips made within the DF itself, between the outer rings and the central zone.

Due to the high trip volumes in the Federal District, the transport authority is considering development of elevated toll expressways on the most congested facilities. However, if some form of traffic management using intelligent transportation systems or congestion pricing is considered, it is possible that it may lead to more efficient use of existing infrastructure, to not warrant the need for these investments. As stated earlier, for a congestion pricing policy to be successful, the availability of reliable and accessible public transport is essential. The Bus Rapid Transit (BRT) corridors being constructed two of the city’s main arteries provide a key step in this direction, as they are linked with the central business district. These should ideally be fully operational before any form of congestion control is instituted. One possibility could be to consider charging for use of some lanes on the proposed BRT corridors. All the options stated in this section are possible with varying potential impacts, and deserve further analysis.

The arguments above suggest that if area-based criteria are considered for congestion pricing, they would be more viable if applied in the DF area. In such a case, it is important for the DF transport authority, SETRAVI to be involved in designing and implementing congestion pricing. SETRAVI operates transit services and road transport in the DF and thus would be best equipped to manage the allocation of revenues to other required services. The DF government has recently also passed a law to explore new
sources of revenue generation for a transit trust fund\textsuperscript{81}. The objectives of SETRAVI’s Comprehensive Program for Traffic and Transport (2001-2006) are better use of resources, enhanced mobility, and preservation of the environment. Congestion pricing is a policy measure that would help achieve all these goals, to some extent, by more balanced use of roads between public and private modes, reduction in travel delays, and some reduction in emissions. It could be implemented as a complement to the high-profile Centro Historico project to improve the old historic center of the city, and the Bus Rapid Transit corridors described earlier.

However, before congestion pricing is considered for Mexico City, there are certain prerequisites that must be addressed. These predominantly relate to resolving the equity issues that often arise against congestion pricing\textsuperscript{82}. First of all, people must acknowledge that congestion is a serious problem in the city, that it leads to a loss in productivity, and that the existing situation cannot be permitted to get any worse. Second, is the issue of providing options for low-income car users, who would spend a higher proportion of their income on commuting. Alternatives must be provided in terms of public transport improvements, so that those who cannot afford a congestion charge do not face a mobility restraint. Third, is the implementation of complementary measures to reduce demand for using private automobiles, such as increasing parking charges in dense urban areas, creating pedestrian-only or bus-only zones, and cycling tracks. Fourth, is to decide how the revenues will be used, as this is critical for the perception of equity and for mitigating negative distributive impacts. Finally, extensive public information about the impacts of congestion and the motivations for pricing is necessary along with building support and negotiating with concerned stakeholders, including government agencies, businesses, informal vendors, car owners, automobile manufacturers, public transport operators, and so on.

To begin addressing the equity concerns, it is important to understand the car ownership profile of the Mexico City Metropolitan Area. This is discussed in the following section.

\textsuperscript{81} Molina and Molina (2002), p. 271.
\textsuperscript{82} Section 2.5 in Chapter 2 of this thesis presents a detailed discussion on what the equity-related arguments against congestion pricing are.
4.5. Growth in Car Ownership in the MCMA

To establish how critical the equity argument is with respect to congestion pricing, we need to understand how car ownership has grown in Mexico City in recent years (between 1994 and 2000). The datasets used to analyze the growth in car ownership are the Origin-Destination Survey data from 1994, and census data from the year 2000. The following figures show the various classes of income, represented as a multiple of minimum wage, and the percentage of population in each income class that owned at least one car in 1994 and 2000. The data from the 2000 census was available for much higher income groups, however for the sake of comparison with data available for 1994, these have been excluded.

**FIGURE 4-2 Income and Car Ownership in the MCMA in 1994**

![Income and Car Ownership in the MCMA in 1994](image)

**FIGURE 4-3 Income and Car Ownership in the MCMA in 2000**

![Income and Car Ownership in the MCMA in 2000](image)
These graphs show the characteristic S-curve of increasing car ownership or motorization with increasing income, where car ownership shows a steep rise at the 4 to 5 times minimum wage level. This was the income threshold in 1994, and remained about the same in 2000 too. Detailed car ownership data show that this is also the income level at which a second car became affordable for many households. The 1994 graph shows that about 97% of households in the highest income group owned at least one car. In comparison with 2000, this number appears to have reduced to about 90%.

The data for the year 2000 showed a decline in percentage of car owning households at extremely high income levels. It is not clear whether this is a fault of the data due to incorrect reporting by the highest income people, or due to some other reason. One factor could be the more rapid increase in the number of households in this income group relative to car ownership. In literature, however, there is evidence that the motorization to income relationship takes the form of the Kuznet’s curve, showing a downturn in motorization rate at the highest income levels. According to the Kuznet’s curve, the decline in consumption at high income levels is related to the negative externalities associated with heavy consumption (here consumption alludes to trip-making), that forces some government regulation. This essentially means that as traffic congestion, pollution, travel delays, limited parking, and other inconveniences associated with car usage increase, governments will be compelled to enact regulations to restrict travel demand. Since the richest households can afford to make use of other alternatives, such as changing their housing location to places in close proximity with work places, or using a taxi everyday, and so on, the issue of inequity for poorer people would always arise. It would be interesting to explore the Kuznet’s relationship further in case of Mexico City but it is not directly relevant to the present discussion.

The average income in Mexico City in 1993-94 was about 2 to 3 times minimum wage (7410 pesos). This is equivalent to the 3 to 4 times minimum wage category in 2000, if we consider inflation. This implies that the middle class income in 2000 would be 3 to 4

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83 Talukdar (1997)
84 Villegas-Lopez (2000)
times minimum wage. However, since the middle class covers a wide range from lower to upper middle, it is difficult to say at exactly what income level, people will be unaffected by a congestion charge. Above 10 times minimum wage can be estimated as the level above which, all households are upper middle or upper class, depending on household size. The table below presents car ownership data from the relevant sources, the O-D survey of 1994 and the census data of 2000. Since the sources of both these data sets are not the same, it is possible that measurement errors may have crept in. However, these data give some understanding about the distributive impacts of congestion pricing on different income groups of people.

**Table 4-1 Number of Households and Car Ownership in 1994 and 2000**

<table>
<thead>
<tr>
<th>Income Level</th>
<th>Car Ownership in 1994</th>
<th>Car Ownership in 2000</th>
<th>Change in Distribution of Car Ownership with Income between 1994 and 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Households</td>
<td>No. of car owning HH</td>
<td>As % of all HH</td>
</tr>
<tr>
<td>Upto 4 times minimum wage</td>
<td>1388964</td>
<td>381779</td>
<td>10.97%</td>
</tr>
<tr>
<td>4 to 20 times minimum wage</td>
<td>1985542</td>
<td>800466</td>
<td>23.00%</td>
</tr>
<tr>
<td>Above 20 times minimum wage</td>
<td>105654</td>
<td>98837</td>
<td>2.84%</td>
</tr>
<tr>
<td>Total</td>
<td>3480160</td>
<td>1281082</td>
<td>36.81%</td>
</tr>
</tbody>
</table>

Comparing the tables above, we find that the number of car owning households has doubled in the highest income group (above 20 times minimum wage) between 1994 and 2000, while the lower and middle classes show a small decline in car owning households. If we look at the increase in total number of households, we find a possible reason for this. The number of households in the highest income group has increased by four times. This is a huge increase and can be attributed to the fact that due to rising incomes, a large number of middle and upper middle class households transitioned to the upper class. It is
thus evident that almost all the growth in car owning households has occurred in the highest income group. The figures below make this point more clearly.

**FIGURE 4-4** Car Owning Households as Percentage of Total Car Owning Households in each Income Group

![Graph showing car owning households as percentage of total car owning households in each income group.](image)

**FIGURE 4-5** Change in Number of Households and Car Ownership from 1994 to 2000, by Income Group

![Graph showing change in number of households and car ownership from 1994 to 2000, by income group.](image)

To understand the decline in lower and middle class car ownership, it is important to study how household income has grown between 1994 and 2000. The daily wage rate has increased by 1.5 times in this period, while inflation increased by 2.25 times. This
implies a 23% reduction in real wages. Thus, we can hypothesize that car affordability may have reduced among those classes of the population that are directly affected by the wage rate, i.e., the lower and middle classes. The reduced affordability of cars may have contributed to the observed high rise in colectivo mode share, from 49% to 58% between 1994 and 2000, as colectivos provide more flexibility than other public transport modes in Mexico City.

While the decline in lower and middle-income car ownership relative to 1994 is small in terms of percentage (Figure 4-4), the absolute numbers of car drivers in these classes is large. This is especially true for the middle class because the largest proportion of households fall in that income category. In the United States, an income level below three times the minimum wage is considered low-income. Considering a conservative level of five times minimum wage below which households are low-income in the MCMA, 12.3% of households in the were low income and owned cars in 2000. Considering a level of ten times minimum wage below which households would be considerably affected by a congestion charge (middle to lower middle class households), 21.7% of total households in 2000 come in this category. This is a significant number, due to which the issue of equity in congestion pricing remains difficult to resolve.

There is no doubt that a large number of car users with modest incomes would have to bear extra costs, but the important point here is that it is the pace of growth in car ownership and use that we are concerned about. Most of the growth in car ownership has occurred in the highest income groups in the period 1994-2000, and this is what needs to be controlled. Congestion pricing is not an egalitarian policy, yet it can be made so, by providing revenues towards ensuring that these households are provided with high quality public transport options. With revenues that can be directly used for transportation investments, it may be possible to shift some of these car users to public transport.

About 65% of households in the metropolitan area do not own cars, yet they suffer the consequences of congestion, travel delays and unreliable public transport. Thus, if the equity issue in congestion pricing is reframed to consider the majority of households not
owning cars at all, the benefits may outweigh the costs. It may be more politically feasible to create discounts, deductions, or credit schemes for lower income households, than it will be to control growth in car ownership in the highest income households. Incomes are bound to rise with economic growth, and it will always be the upper income households that can afford to own and use multiple cars. Therefore the concern arises that since the upper income households will be less sensitive to increased costs, even a high congestion charge may not be enough to facilitate a change in their travel behavior.

The steep rise in colectivo mode share and high income car ownership in the last decade suggest two priorities for managing congestion:

- Control of car use through demand restraint measures such as pricing, and
- Provision of more efficient public transport to serve as an alternative to cars and colectivos, including restructuring the colectivo services

Both these actions must be implemented together. In recent years, the various transportation agencies in Mexico City have been considering public transport improvements, such as the Bus Rapid Transit corridors, and expansion of the Metro network into the State of Mexico. The BRT corridors will be an important development as they will allow replacement of the colectivos on two high demand corridors, thus causing a reduction in colectivo mode share and reducing congestion in parts of the city. Policies that transfer colectivo driver livelihoods to the BRT system may have to be incorporated if this is done. Plans to reorganize the colectivo sector have also been proposed, however, no consideration has been given to controlling car use to manage congestion.

The Hoy No Circula program was designed to reduce air pollution, but the coercive nature of the policy and the absence of alternatives make it economically inefficient. It also imposes extra costs on car owners by forcing them to not drive on a certain day, whereas in case of congestion pricing, drivers can choose to drive and pay a charge for essential trips. Congestion pricing will not only reduce travel delays and congestion, but the resources generated can be re-allocated for larger welfare, such as public transport.

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85 Described in Section 4.3 of this chapter.
improvements. This will help ease the mobility restraints that lower income people will face. The use of revenues is in fact, one of the important factors that will determine support for a pricing scheme. Considering congestion pricing to be a viable solution in the Mexican context, different pricing options are discussed in the next section.

### 4.6. Possibilities for Type of Scheme and Area of Operation

An analysis of the Origin-Destination Survey data for 1994 revealed that the highest number of peak hour trips are made in the central districts of the MCMA. The maps in Figure 4-6 show the district locations that were trip destinations during the morning peak hours between 7 to 9 AM. The dark red shading shows areas that were destinations to the highest number of trips, with the lighter shade showing progressively lower number of trips. Data for all hours in the day, from 5 AM to 6 PM were analyzed, and the central districts constantly remained dark red, i.e. they were destinations to most trips for most of the day. The picture below reverses during the evening peak hours between 5 to 7 PM, where the dark red portion represents origins for largest number of trips.

**Figure 4-6 Sample of Trip Destinations During Morning Peak Hour, 1994**

These maps show that there is indeed a “hot zone”, where trips are destined during virtually all hours of the day, up to 6 pm, making this zone the most congested, especially
during peak hours. Thus, it may be possible to formulate a charge that would be paid by all private vehicles entering this zone during certain hours of the day. This idea is similar to the Area Licensing Scheme in Singapore, where vehicles are charged for driving into the central business district, and also the London Congestion Charging scheme, where, barring certain special categories of vehicles and taxis, all other vehicles have to pay a fee for entering Central London during the day. In earlier stages of this research, the possibility of an area-based charge was not considered because of the assumption that employment and trips in Mexico City are quite decentralized. However, this assumption has been proved wrong from the O-D data analysis. It now appears worthwhile to consider a London-type scheme, since the central zone would undoubtedly be most congested during a large part of the day. This zone more or less lies in the area bounded by the Circuito Interior - a controlled access road. While it is not possible to directly draw inferences for Mexico City based on the London case, it appears that an area-based charge might be necessary in the MCMA because over 60% of automobile trips occur within 10 km from the city center.

**FIGURE 4-7 ROAD NETWORK IN THE FEDERAL DISTRICT**

![Road Network in the Federal District](source: SETRAVI (2001), Comprehensive Traffic and Transportation Program)

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86 COMETRAVI (1999)
Area-based charging could be considered in the central 21 distritos (districts) of the three most congested delegaciones of the DF – Cuauhtemoc, Benito Juarez, and parts of Miguel Hidalgo. These districts comprise most commercial, services, and government establishments in the metropolitan area and thus, they are attractions for most of the morning peak hour trips.

Congestion in these areas is also caused due to the presence of the highest percentage of the city’s on street free parking. It is about one-half to one-third of the total parking in these districts, with much of the rest being employer-paid parking. Simply charging for parking could be one way to reduce the number of vehicles in the area, however, the demand elasticity of car use with respect to parking prices is usually quite low. It may not be possible to set parking charges that are high enough to deter people from driving to these congested parts.

Since car drivers coming to the central parts of the city have mostly never paid for road use or parking, it will be important to cultivate a “culture” of paying for road use. Parking meters must be installed in these districts, at least to start with. A phased process is recommended, whereby parking surcharges are constituted first, followed by area-based congestion pricing during certain hours, in the central districts of the city.

A proposed Central City Congestion Zone comprising these districts is shown in Figure 4-8. In later stages, once public response to a congestion charge is known, peak period pricing could be implemented on the major facilities linking the EM and the DF, or the zone can be expanded up to the Periferico beltway. Facility pricing however, might be perceived as a restraint imposed on people from the State of Mexico from accessing the Federal District. It is thus better to implement this form of pricing on the proposed Bus Rapid Corridors so that there is a good quality travel alternative on the same routes.
The area covered by the proposed Central City Congestion Zone, including 21 central districts of the DF, is a small proportion of the total metropolitan area. This zone has other characteristics that make it viable for pricing measures. One, the dense Metro coverage in this area provides a good alternative to car use. Although some argue that the same people that use cars in this area will never use the metro, the availability of reliable public transit is the first prerequisite for implementing pricing in the area.
Second, while the large proportion of on-street parking contributes significantly to congestion, the initial step of introducing parking meters in the three central delegaciones is already underway. There are other options that can be considered specifically to deal with the significant proportion of employer-paid parking in these areas. An idea that has been studied in depth by Shoup and Wilson, generating good results in the Los Angeles area, is that of ‘parking cash out’\textsuperscript{87}. Employer-paid parking contributes to a tendency to commute alone to work, according to Shoup and Wilson, thereby increasing traffic volumes. In this system, employers pay employees an amount equal to the parking subsidy as an incentive for not driving to work. The choice between a free parking space and cash makes it clear that parking has an opportunity cost, which is the cash not taken. In Los Angeles, the policy has resulted in more people driving in car pools, or using public transport in order to avail of the incentive, while the freed up parking space is leased out at market values. Parking cash out is a useful idea if considered for parking lots; yet, in case of Mexico City, it is on street parking that contributes most to congestion in the central areas.

One of the chief issues we need to consider is that of the distributive impacts of a congestion charge, and the question of whether a scheme would be progressive or regressive. In his essay titled ‘Equity Issues’\textsuperscript{88}, Hodge presents the distinction between relative and absolute burden of a tax or user charge. Views regarding equity impacts of a proposed scheme depend on whether the absolute or relative burden is considered as an indicator\textsuperscript{89}.

If the absolute amounts are considered in the case of say, a central city congestion charging fee or high parking charges in Mexico City, then wealthier households will absorb the higher burden as they own and use cars more. This makes the scheme progressive. For example, the London scheme is considered to be progressive because only about 10\% of low income households actually own and use cars, given the heavily used public transportation system in the city.

\textsuperscript{87} Shoup and Wilson (1992)
\textsuperscript{89} Ibid.
However, if a congestion charge is viewed in terms of proportion of household income spent towards it then the relative burden is higher for low-income households, making the charge regressive. Due to the socio-spatial segregation seen in Mexico City, the high car ownership among people with higher incomes, and inherently geographic nature of traffic congestion, an area-based charging scheme is bound to be regressive in the relative sense, but progressive in the absolute sense. The goal then must be to introduce certain measures that eliminate the proportionally higher burden that low-income households will bear.

Some ways to do this could be designed into the policy itself, such as discounts for people residing in the charging zone and for taxi drivers, as is done in London. A high proportion of lower income households in Mexico City are located in and around the city center. For the rest, there could be deductions claimed on income tax, based on the level of income. Given the concern that many people in developing countries do not even pay taxes, the deduction could be claimed on the vehicle registration fee (‘tenencia’ in Mexico City) based on some proof of income such as an income tax return, bank account statement or most recent payroll receipt.

There could also be a regulation that allows people to purchase an area-accessing license as in Singapore. Anyone applying for a drivers license can have the option of purchasing the area license for a fee that would be discounted for people below a certain threshold of household income. These however, are ideas that are difficult to enforce and monitor in a developing city, unless there is sufficient institutional strength. Corruption and unreliable citizen records add to the problem of enforcement.

There are of course, details that will have to be worked out depending on the technical features and geographical scope of the type of congestion charging scheme considered. A detailed analysis of the different travelers or user groups driving into the central city areas, and the purpose of their trips, is central to understanding and demarcating a ‘congestion zone’.
A major challenge before any such scheme is considered is that of improving the image of the metro and of public transport in general in Mexico City. Middle and upper class travelers are reluctant to use the metro or colectivos for many reasons. The metro stations are unsafe, and chaotic with informal businesses and vendors, and their entrances are crowded with colectivo operators aggressively looking for passengers, especially during rush hours. Petty crimes are often committed in the metro stations, and there is the perception that it is meant for the lower classes, since the metro at present mostly reaches poor neighborhoods. In addition, relatively lower income people from the EM neighborhoods take colectivos to the nearest metro station and then transfer to the metro to travel into the DF. Social segregation is high in the city and since most metro riders are from the lower socioeconomic levels, people from the middle and upper classes choose not to travel with them. While a lot of these people have to travel to their jobs in the downtown, they would rather drive on congested streets than ride the metro. The car of course, is also perceived as a symbol of higher social status.

### 4.7. Recommendations for a Phased Strategy

First of all, it is essential to engage stakeholders, and facilitate rigorous public information regarding the costs and benefits of the proposed measures. The main stakeholders that would be affected by congestion pricing would be public sector agencies responsible for the initial administrative, operational and enforcement costs they would incur, along with responsibilities for revenue allocation. Other interest groups will include car owners, colectivo owners, taxi drivers, and freight operators, who would face higher operating costs, public transport riders who stand to gain from increased investments, businesses and vendors in the central area, residents in and around the congestion zone, and indeed, all citizens affected by travel delays and air pollution in the city.

The following steps are recommended as a broad phased strategy in considering implementation of congestion pricing in Mexico City. As mentioned earlier, the mentality of paying for road use in congested areas can only be cultivated slowly. Thus,

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this strategy can be phased over 5 or 6 years. It is essential that the current transport and environment agencies work in close coordination to successfully implement the following measures. A robust institutional setup is necessary to plan, implement and enforce these measures.

**Step 1**: The Bus Rapid Transit corridors in Mexico City are expected to be in operation in 2005. By that time, parking charges must be in force in the central delegaciones by means of parking meters or manual collection. The charges must be enforced and the revenues must be used to improve other transport services. Throughout this period, extensive public information is essential, regarding the costs of congestion and use of potential revenues. There are already many ongoing transportation developments in Mexico City that set the stage for these recommendations. Installation of parking meters in the central delegaciones of the DF has already been proposed.

**Step 2**: Drawing on the public information, a thorough stakeholder engagement process must begin to present analyses about various pricing schemes that could be considered, with potential costs, benefits, and distributive impacts of each. To do this, it is important to have a good estimate of the demand elasticity of private trips in the city, for each income group of travelers. A new Origin-Destination survey would be a first step in obtaining this data. In addition, the vehicle registration records of the DF and EM must be improved to form a reliable database.

**Step 3**: As the operation, collection, and use of parking charges becomes efficient, area-based charging must be considered in the central 3 delegaciones or the 21 distritos recommended earlier. The stakeholder engagement process in Step 2 may lead to other more viable pricing options not discussed here, for example peak hour pricing on the main facilities. Any option that is considered best under expert scrutiny, and with most stakeholder consensus, should be considered. This will most likely be part of a package of measures specifying alternatives for people who would be priced out of driving their cars, and the use of revenues.
As a first step towards stakeholder engagement, an informal survey was conducted among government officials in Mexico City at the Seventh Mexico City Air Quality Workshop in January 2004. The results of the survey are presented in the next section.

4.8. Communicating with Stakeholders: Survey Results

In an earlier stage of this research, there did not seem to be much interest among transport professionals in Mexico City with regards to the idea of congestion pricing. However, in January 2004, when the idea was introduced to officials in Mexico City at the MIT Annual Workshop, it resulted in a 3-hour long open discussion about their concerns and questions. At this time, after the first year of the London Congestion Charging scheme, there was a lot more information regarding possible distributive consequences. The fact there is deep concern over the problem of congestion in Mexico City is evident.

A survey to answer ten questions in thinking about congestion pricing for Mexico City was designed, and it was circulated among the transportation and environment experts present on the last day of the Annual Workshop. These included officials from various levels of government agencies, responsible for transportation and environment policies in the region such as SETRAVI, SMA, STC, SEMARNAT, CAM, and the Mayor’s office. They also included many academics and professional consultants with an interest in improving air quality in Mexico City. The response rate was 69% with a total of 72 responses from the 105 questionnaires handed out. The respondents included the MIT group and other non-Mexicans but their responses have been filtered out in this analysis.

4.8.1. Purpose of the Survey

The reason for circulating the survey in this forum was to understand the views of experts and decision-makers in the city on the issue of congestion pricing. We expect that a congestion pricing policy in Mexico City would involve collaboration between the transportation and environmental agencies. Congestion pricing may have a small impact on reducing air pollution. But air quality being a foremost area of interest in Mexico City, we find that the DF’s environmental agency (SMA) works closely with the
transportation agency (SETRAVI) to coordinate transportation measures that will help reduce emissions in any capacity. With regards to implementing congestion pricing, it is necessary that these people in a position of power are convinced of the idea before it is introduced to the public at large.

The survey is useful for understanding the current policy climate and people’s leanings with respect to pricing. It is not a definitive statement of public reactions to the policy, but only a tool to help guide my research so my recommendations are better informed. It is widely recognized that thorough public information regarding the costs and benefits of congestion pricing is very essential for public acceptability. The first prerequisite for this is that the decision-makers themselves be convinced of the gains from a pricing policy. The fact that most of these people also use private cars to commute in Mexico City is important as well, in order to understand their “personal” responses. It is likely that they may be undecided about their stand on congestion pricing and its effectiveness, since they are directly impacted by the policies they implement. But by surveying a sample of stakeholders who would be among the most vocal and influential opponents to any form of congestion pricing, potentially worst-case responses were received.

For most questions that provided different options as possible answers, people were asked to rank the options. This is because in order to understand how congestion pricing may be implemented in a carefully sequenced package of measures, the ranking is necessary to understand what options people consider more essential at a specific time and for a specific purpose. The various options were designed after a literature review of the experiences of cities around the world that have implemented pricing in some form. In designing the options, we also reviewed the possible arguments people give when they adopt a stand for or against a pricing policy. One respondent criticized the survey saying that it was designed to lead the answer. But in all questions, there was an option for “Other” where people could put down any other choice they felt was important. Presenting people with different options to choose from speeded up the response time. It also facilitates corroboration of some standard policies usually suggested to alleviate congestion that people believe should be considered before congestion pricing. These
include constructing more roads, improving public transport, raising parking fees, and so on. We argue that these are not far reaching in terms of impacts, and are only short-term solutions.

The questions in the survey can best be answered when the geographical scope and technological breadth of the pricing scheme is known, that is, when we know what the charges would be, what area or links it would cover, the technology used, the mode of payment, and so on. This is especially true for questions such as which stakeholder group would be most resistant to the policy, which agency should lead efforts and how effective the policy will be in managing congestion. However, the responses fit well with an intuitive understanding of how people react to pricing policies when they are first suggested. These responses also help anticipate public reactions to specific measures. It is necessary to consider these reactions and adapt policies before they are presented to the people. The following analysis disregards the non-Mexican respondents and only presents the views of the 50 Mexicans (about 70% of total respondents).

4.8.2. Detailed Results: Questions and Responses

1) Familiarity with pricing and the problem of traffic congestion in Mexico City

The questionnaire gave a brief overview of the main objectives of congestion pricing and what the policy entails. The results showed that 50% of the Mexican respondents were familiar with the concept of congestion pricing and 38% were not completely familiar. These results are would not have been affected by the lack of knowledge on congestion pricing because the questions were related to standard policy measures that the respondents would be expected to understand. This is indicated by the fact that all the questions had responses.
88% of respondents thought that the problem of traffic congestion in Mexico City is in a critical stage today and 12% thought it was a reasonable problem. Nobody thought that it was still not a problem.

2) Worst Impact of Traffic Congestion in Mexico City

Loss in productivity and overall quality of life was considered the worst impact of traffic congestion in Mexico City by 52% of people. They ranked it #1. 29% of people ranked air pollution #1 as the worst impact. Air pollution and associated health impacts by exposure were ranked #2 by 56% of respondents. Travel delays were ranked #3 by 42% of people, followed by high fuel/infrastructure costs, ranked #3 by 28% of people. Productivity and quality of life is directly dependent on travel delays. Even though it was a separate option in the questionnaire, if we add them up, we can infer that 63% of
respondents ranked the combined option as #1. Overall, the ranking is travel delays, loss of productivity and quality of life as #1, followed by air pollution as #2 and high fuel/infrastructure costs as #3.

**FIGURE 4-11** Ranking of Impacts of Traffic Congestion in the MCMA

![Bar chart showing rankings of impacts of traffic congestion](chart)

**FIGURE 4-12** Worst Impacts of Traffic Congestion in Mexico City

*(Responses Ranked #1)*

![Pie chart showing worst impacts](chart)

Note: Responses that cited “health effects due to pollutants” as the worst impact have been included in the Air Pollution category.
3) Best Way to Deal With Traffic Congestion

49% of respondents thought that improving public transport and using physical restraints such as bus-only lanes and pedestrian zones were the best way to deal with traffic congestion. 11% thought that bans such as the Hoy No Circula were the best. 9% thought that congestion pricing was the best way, 9% thought that parking reform was most important and only 2% thought that increasing road capacity was the best way. These were the responses ranked #1. 20% of people thought that the answer lies in using a combination of policies, of which improving public transport and using physical restraints were as important as higher parking charges in congested areas, these being the most popular policies.

The option of higher parking charges was ranked #2 by most respondents (31%), followed by improved public transport and physical restraints. At Rank #3, expanding road capacity was picked by 25% of respondents and congestion pricing by 24% respondents. If we only look at the two top ranks together, the best way to deal with congestion was to improve public transport and use physical restraints (37% respondents), followed by higher parking charges in congested areas (19%). If we look at the two lowest ranked policies together (options 5 and 6), expanding road capacity was picked by most people, closely followed by the Hoy No Circula and then by congestion pricing. Expanding road capacity is clearly the lowest choice for measures to manage congestion. The Hoy No Circula program does not appear popular either.

**FIGURE 4-13  Ranking of Preferred Policies to Manage Congestion in the MCMA**
4) Best Option for Raising Revenues

For raising revenues, congestion pricing was picked by most people, 44% of respondents, as the best option, followed by higher parking charges in congested areas, picked by 28% of respondents. 2% of respondents suggested that road capacity could be expanded, with tolls that would generate revenues.

**Figure 4-14  Ranking of Policies Considered Best for Raising Revenues**

5) Option Most Acceptable to Public

Most people, 37% of respondents, ranked public transport improvements and physical restraints as Rank #1. This was closely followed by expanding infrastructure and increasing road capacity, picked by 35% of people. Only 2% of respondents ranked congestion pricing as Rank #1. If we look at Ranks 1 and 2 together, on average, 33% of respondents thought Option D – physical restraints and public transport improvements would be most acceptable to the public, followed by expanding road capacity (27%), followed by higher parking charges (24%). In terms of number of people who ranked a particular policy 1, 2 or 3 for public acceptability, a ban such as Hoy No Circula was considered even more acceptable than congestion pricing as most people ranked it #3.
6) Stakeholder Group Expected to Have Most Resistance to a Pricing Policy

58% of respondents thought car owners would be most resistant to any form of pricing policy (including higher parking charges), followed by 30% who thought that colectivo and taxi drivers would be most resistant. These percentages are for responses ranked #1. Overall, looking at ranks 1 and 2, it was believed that car owners would be most resistant to pricing (49%), followed by colectivo/taxi drivers (31%), then freight operators (10%)
and lastly, businesses (6%). 4% of the responses stated “Politicians” in the ‘Other’ category as another stakeholder group that would resist the policy.

**FIGURE 4-17 Ranking of Stakeholder Groups Expected to be most Resistant to Congestion Pricing**

![Bar chart showing ranking of stakeholder groups](chart)

Note: The respondents who chose the option “Other”, specified their choice as “Politicians”

**7) Use of Pricing Revenues**

60% of respondents ranked road and public transport improvements as #1, followed by 24% of respondents who thought the revenues should be used to set up a general fund for health, education and welfare projects. 10% thought the revenues should be used for increasing institutional capacity in terms of physical resources and human skills. 6% of respondents were in favor of using the revenues for tax reductions/subsidies such as reduction in the car ownership tax ‘tenencia’. These are the percentages for Rank 1. This is broadly the ordering of preferred responses even if we look across all the ranks.
8) Agency that should Lead Efforts to Implement Congestion Pricing in Mexico City

Most people thought that all the agencies should collaborate. The choices included the Mayor’s office, the transportation agency for the DF (SETRAVI), the environmental agency for the DF (SMA), the metropolitan transport agency (COMETRAVI) and the metropolitan environmental agency (CAM). 40% of respondents answered “All these”. 20% thought that the lead should be taken by the Mayor’s office, the way it is in London. 16% thought that the CAM should be responsible, followed by the SETRAVI (6% respondents) and lastly the SMA (8% respondents). Some people pointed out that the DF And the EM agencies should work together with the metropolitan level agencies.
9) Biggest Challenges for Implementing Congestion Pricing in Mexico City

For options ranked #1, the highest percentage of respondents, i.e. 32%, considered public resistance as the biggest challenge. 25% considered political conflicts as the biggest challenge, followed by 21% respondents who thought the main problem was fragmented institutions. Lack of alternatives to driving was considered a major problem by 10% of respondents. While the lowest percentage of people thought that poor enforcement should rank #1, a significantly higher percentage thought that it should rank #2 or #3. Thus, overall, the top 3 ranks showed that most people consider political conflicts the biggest problem, followed closely by public resistance.

This is followed by fragmented institutions, then by poor enforcement and finally by lack of alternatives to driving. In fact, if we look at the lowest ranked options together (ranks 6 and 7), vandalism of traffic cameras and installations was considered the least important issue (by 35% of respondents), followed by lack of funds (24% of respondents). If we only consider the lowest rank (rank 7), more than half the respondents (55%) ranked vandalism of traffic cameras as the last rank, showing that it was the least important issue, followed by lack of funds (20%).

**Figure 4-20  Ranking of Main Challenges to Implementing Pricing in the MCMA**

![Bar chart showing the ranking of main challenges.](image-url)
10) Other Insightful Responses

For the best way to deal with traffic congestion in Mexico City, one respondent introduced the policy of ‘controlled hours for delivery trucks, say 3-6 am and 7-10 pm’ as an option to deal with congestion. She ranked it #3. She reformed Option A to include payments for parking violations, added to higher charges in congested areas and ranks it #1. She reformed Option C to increase the number of days a vehicle is banned in the Hoy No Circula program and to include taxis and colectivos too. She ranked this option #2. She said that a public campaign should be launched in the media, TV, radio and newspapers to people about the implications of reckless driving and lack of respect for driving rules on health, quality of life, transport expenses, and so on.

Another respondent introduced the idea of strict enforcement and making drivers abide by laws such as having microbuses use only one lane of the road. One respondent modified Option E – expanding infrastructure and road capacity, to include toll roads. Then, in the question about which option would be best for raising revenues, she ranked the toll road option as #2 after congestion pricing.
One respondent said that corruption was the biggest challenge in considering a pricing policy for Mexico City. Since people had limited trust in the government, it would be assumed that any additional tax would be stolen by a group of people and would not be used to benefit society. Also, if more fines or taxes were imposed, it would lead to increased bribery and corruption. She said that people would prefer using free congested roads to using congestion-free toll roads, which are very expensive so very few people use them. She mentioned raising the gasoline tax and using the funds to improve the quality of fuel as a way to improve air quality. Two respondents pointed out that lack of security in public transport is a major challenge and the fear of being assaulted is the reason people prefer to use private vehicles. Another respondent said that the biggest challenge was the lack of sound policy instruments.

Two respondents suggested that for the question on biggest challenges, the options might have causal links with each other. For example, public resistance and lack of alternatives to driving may be the same problem, the latter being the cause of the former. Similarly fragmented institutions and political conflicts may be directly related. I looked at the analysis again after combining these sets of options. If we look at the top two ranks, highest percentage of people said the biggest challenge was the combined option of public resistance/lack of driving alternatives, followed by the combined option of fragmented institutions and political conflicts, then by poor enforcement. Thus, the main results remain the same. It is not the lack of resources, poor enforcement or vandalism that is the main challenge to overcome, as one would imagine for a developing world city. Rather, it is the deeper problems of institutions, politics and traveler mindsets that will lead to resistance.

4.8.3. Summary of Survey Results
The results from the survey directly inform the following two research questions stated in Section 1.5 of this thesis:

- Would congestion pricing be effective in improving urban transport in Mexico City? If so, what opportunities and constraints would be faced in implementing it?
- How can the various stakeholder interests be addressed to make the policy publicly and politically acceptable in Mexico City?
Many transportation experts disregard the policy of congestion pricing on the grounds of equity, more so in the developing world where social and income inequalities are very high. There is limited institutional coordination, limited resources, lack of alternatives to using the private vehicle, poor enforcement of traffic and parking regulations, higher rates of crime and vandalism of public property and a higher number of low-income car drivers. These challenges are usually generalized across large and rapidly growing cities of the developing world. However, only some of these are true for Mexico City. The survey results show that the lack of funds, vandalism, or lack of alternatives to driving, are far lower on the list of most important challenges than public resistance, fragmented institutions or political conflicts.

Only 22% of total trips in Mexico City were made by private car in 1995. Colectivos and buses were used to make 55% of the trips in 1995. INEGI’s Origin-Destination Survey of 1994 showed that only 36% of total households in Mexico City are at the income level where they can afford to own and use cars. Thus, if 64% of the households do not own cars and use public transport (includes colectivo, bus and taxi trips), then there is the potential to design a fair pricing policy where revenues from charging car users are usefully diverted to improve public transport, as done in the London Congestion Charging scheme.

It appears that public resistance to congestion pricing in Mexico City is more an issue of driver ‘culture’ or ‘mindset’ than of lower income. Drivers currently use their cars with minimal out-of-pocket costs. The extra costs they experience through congestion are not tangible or quantifiable and hence they are simply not known. Therefore, the equity issue in case of Mexico City is the reverse of what we see in many American cities. There are few low-income drivers. People with higher incomes drive and those with lower incomes use the buses, colectivos or the metro. It is fairer and more equitable to charge low capacity cars in order to improve the high capacity modes used by most of the population.

The Government of the DF is already implementing bus rapid transit on two busy corridors in the city, to be in operation by the middle of 2005. An integrated transport
strategy of consolidating colectivo trips into improved bus transportation, parking reforms and congestion pricing may be the way ahead for reducing traffic congestion in the city. The acknowledgement that congestion is a serious problem in Mexico City is a primary step for this. We have seen from the cases of London and Singapore that when congestion pricing is initially implemented, it invariably faces public resistance. But when the revenues are used for larger visible benefits then the idea seems more positive. Unlike a gasoline tax that is applied to a larger population base with smaller per capita effect, a congestion charge is better directed at a smaller base with higher impact. The London Congestion Charging scheme has actually proven itself progressive in this regard and important lessons can be drawn from its first year of implementation. This section discusses the results of the survey in detail. The main points are summarized below.

1) There is a great deal of ambiguity surrounding the idea of congestion pricing, even among experts. Public information regarding the motivations for congestion pricing is very important.

2) It is clearly acknowledged that traffic congestion in Mexico City today is a critical problem.

3) The worst impact of traffic congestion is on quality of life and lack of productivity resulting from travel delays. Air pollution ranks next.

4) The best way to deal with traffic congestion is to improve public transport and have physical restraints such as bus-only lanes and pedestrian zones. Increased parking charges in congested areas ranked after this. A combination of policies was considered important.

5) Congestion pricing was considered the best option for raising revenues, followed by higher parking charges.

6) The measure most acceptable to people would be to improve public transport and use physical restraints, closely followed by expanding road capacity. Congestion pricing was ranked lowest.

7) Car owners would be most resistant to a pricing policy followed by colectivo/taxi drivers.
8) The revenues from a possible pricing scheme would be best used for road and public transport improvements, that is, they ought to remain within the transportation sector itself.

9) All transportation and environment agencies should coordinate efforts with regard to a pricing policy. When singled out, the Mayor’s office was considered best to take the lead.

10) Public resistance was considered the biggest challenge in implementing congestion pricing, followed by political conflicts.

These results are intuitive and match with the initial conditions present in other cities where congestion pricing has been implemented. They are useful to understand what the next steps are for resolving the congestion problem in Mexico City, whether towards improving institutional coordination between the different level of transport and environment organizations, improving public transport, modifying the Hoy No Circula, or others. The results show that traffic congestion is a serious problem by itself. Strategies to resolve it need not hinge on air quality control measures. Reducing congestion obviously has significant positive impacts on emissions reduction, but not to the same scale. This is especially true because a congestion pricing scheme, if implemented, must initially be small in scale. When its impacts are ascertained, then it can be expanded or altered, as is being considered for London now.

After this detailed background on transportation in the MCMA and a sample of responses from Mexicans towards congestion pricing, let us now try to quantify some impacts that might result from a pricing policy. The next chapter presents different levels of analysis to estimate potential reductions in trips, and emissions, resulting from the introduction of a ‘congestion zone’ as recommended in this chapter.
CHAPTER 5. ANALYSIS OF POTENTIAL IMPACTS

5.1. Objective of Analysis

The goal of the work presented in this chapter is to empirically estimate the possible savings in travel time, reduction in trips, and reduction in emissions by private automobiles in Mexico City as a result of implementing an area-based congestion pricing scheme as described in Chapter 4. The data used here is from the Origin-Destination survey (O-D) for Mexico City conducted by the National Statistics Institute (INEGI) in cooperation with the Federal District in 1994. The O-D survey was based on 135 distritos (districts), representing a 135*135 origin-destination matrix, with information on 29.1 million trip segments. The households that surveyed were demographic samples representing the entire population of the metropolitan area. This is the latest O-D survey conducted for Mexico City, with previous such surveys done in 1977 and 1983.

There are obvious limitations of using these data for our analysis, as at the time of this research, the data are already 10 years old. Yet, they provide an important understanding of the mobility picture at that time, from which trends for the future can be determined. In addition, the mode split for public transport obtained from the survey is likely to contain a high degree of error because the data refer to unlinked trips, or segments of a trip made on a single mode of transport. The number of trips on the publicly controlled modes – metro, trolley bus, light rail and Ruta 100 bus were based on ticket sales and turnstile registers. However, the data for privately operated modes such as cars, taxis and colectivos, were based on the number of vehicles in circulation and their estimated occupancy rates, thus introducing a likely error91.

The survey provides a snapshot of travel demand in the MCMA in 1994 and its results can be used to understand the factors affecting demand such as income, distance between origin and destination, trip duration, availability of public transport, and so on. We can thus suggest how demand would change in the future with changes in these influencing

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factors. After studying the data from the O-D Survey, we selected 21 central contiguous distritos (districts) in the Federal District (DF) bounded in whole or part by the Circuito Interior (inner ring road) to form a potential ‘congestion zone’ for the purpose of analysis. This is shown in Figure 5-1. The distritos part of this zone, are destinations to the maximum number of work trips in the metropolitan area and are listed in Table 5-1. They also include the main nodes of business and commerce in the metropolitan area.

**FIGURE 5-1** Map of Federal District Showing Metro Network and Central Areas

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**Legend**

- Federal District (DF) Boundary
- *Delegacion* Boundary
- Area bounded by Circuito Interior (proposed congestion zone)
- Area showing four central most congested *delegaciones*
- Existing Metro Network
- Proposed Metro Extension
- New Metro lines proposed
- Boundary of Centro Historico

*Source: STC (1999), Plan de Empresa 2000-2006*
TABLE 5-1  Distritos with the Highest Trip Attractions in the Federal District: Partially or Completely Located in proposed Congestion Zone

<table>
<thead>
<tr>
<th>Distrito No.</th>
<th>Distrito Name</th>
<th>Total trip attractions</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zocalo</td>
<td>567,160</td>
<td>2.76%</td>
</tr>
<tr>
<td>2</td>
<td>Zona Rosa</td>
<td>473,098</td>
<td>2.30%</td>
</tr>
<tr>
<td>3</td>
<td>Buenavista</td>
<td>238,997</td>
<td>1.16%</td>
</tr>
<tr>
<td>4</td>
<td>Tlatelolco</td>
<td>154,124</td>
<td>0.75%</td>
</tr>
<tr>
<td>5</td>
<td>Morelos</td>
<td>241,392</td>
<td>1.17%</td>
</tr>
<tr>
<td>6</td>
<td>Colobrera</td>
<td>254,242</td>
<td>1.24%</td>
</tr>
<tr>
<td>7</td>
<td>Condesa</td>
<td>256,415</td>
<td>1.25%</td>
</tr>
<tr>
<td>8</td>
<td>Chapultepec</td>
<td>379,870</td>
<td>1.85%</td>
</tr>
<tr>
<td>9</td>
<td>Las Lomas</td>
<td>225,778</td>
<td>1.10%</td>
</tr>
<tr>
<td>11</td>
<td>Anahuac</td>
<td>262,621</td>
<td>1.28%</td>
</tr>
<tr>
<td>33</td>
<td>Balbuena</td>
<td>305,326</td>
<td>1.48%</td>
</tr>
<tr>
<td>37</td>
<td>Reforma Iztaccihuatl</td>
<td>170,466</td>
<td>0.83%</td>
</tr>
<tr>
<td>38</td>
<td>Villa de Cortes</td>
<td>161,669</td>
<td>0.79%</td>
</tr>
<tr>
<td>39</td>
<td>Portales</td>
<td>229,357</td>
<td>1.11%</td>
</tr>
<tr>
<td>40</td>
<td>Del Valle</td>
<td>341,179</td>
<td>1.66%</td>
</tr>
<tr>
<td>41</td>
<td>Ciudad de los Deportes</td>
<td>248,370</td>
<td>1.21%</td>
</tr>
<tr>
<td>42</td>
<td>Vertiznarvarte</td>
<td>220,867</td>
<td>1.07%</td>
</tr>
<tr>
<td>43</td>
<td>Plateros</td>
<td>141,032</td>
<td>0.69%</td>
</tr>
<tr>
<td>44</td>
<td>San Angel Inn</td>
<td>382,344</td>
<td>1.86%</td>
</tr>
<tr>
<td>64</td>
<td>Ciudad Universitaria</td>
<td>309,926</td>
<td>1.51%</td>
</tr>
<tr>
<td>65</td>
<td>Viveros</td>
<td>268,258</td>
<td>1.30%</td>
</tr>
<tr>
<td><strong>Total attractions</strong></td>
<td><strong>20,573,725</strong></td>
<td><strong>28.35%</strong></td>
<td></td>
</tr>
</tbody>
</table>

The original O-D Survey consists of a 135*135 matrix with information about trips on all modes from 135 origins and destinations, at the distrito level for the DF and at the municipality level for the EM. To study the applicability of a zone-based charge, a subset of the original O-D dataset was used for this analysis. This included only the trips made by cars and taxis (considered to be private modes) in the morning peak hours between 7 AM to 10 AM to selected central distritos in the DF. The trips were not separated by trip purpose because these distritos receive high trip volumes for most of the day. However, of all trips that are made to this area for various purposes such as work, shopping, recreation, trips back home, and so on, we can reasonably assume that most trips made between 7 AM and 10 AM would be work or study trips. The distritos having the highest concentration of jobs and businesses in the MCMA are all in the DF, and are part of the congestion zone considered for this analysis. These include Zocalo, Morelos, Zona Rosa, Condesa, Chapultepec, Anahuac, Del Valle, and Ciudad de los Deportes.
The data included trips made from all 135 origins in the city from the DF and the EM, to 21 central DF distritos. Thus, a 21*135 O-D matrix was analyzed for which public or private trip data was available. Those O-D pairs for which no public or private trip data was reported were left out. From the total trips made to between each O-D pair, the private (cars and taxis) and the public mode split was calculated. The public modes included the colectivos, buses, light rail, trolley bus, metro, suburban train, and all combinations of these modes.

Regressions were run under different conditions between the following variables, in order to determine their impact on private mode share for all trips whose destination was in the ‘congestion zone’ considered. Thus, the dependent variable was the private transport mode share of trips to the central distritos, and the independent variables used were:

- **INC**: Average per capita income in the origin delegacion or municipality
- **DUR**: Duration of trip
- **COST**: Cost of driving from origins to destinations in city center (excludes parking cost)

Multivariate regression analysis was done to examine the relationship of these factors to the use of private modes. Data from the origin-destination survey represent a wide difference in origins even if the destinations in the analysis are all considered to be within the same central zone. The data are highly scattered, leading to a high standard error if we actually try to estimate values and build a predictive model. Thus, this analysis will focus on establishing correlations between the factors affecting private mode share under several conditions, and on understanding how well the chosen factors explain the observed variance in private mode share of trips.

### 5.2. Assumptions

Private mode share included all trips made by cars and taxis to the central areas of the MCMA. Origin-Destination (O-D) pairs where all reported trips were made using public modes had a private mode share equal to zero, and public mode share equal to one. The private mode share was considered as the dependent variable rather than simply the number of private trips, because the mode share represents the data in a normalized form
that can be compared across O-D Pairs. The private mode share equals the fraction of
trips made using private modes of all reported trips between an O-D pair. Since we are
only interested in the factors affecting private mode choice, using the normalized data
also ensures that the size of the distrito does not affect the results. For example, a larger
distrito would have more private trips simply because it has more destinations, even if the
trip cost is very high.

Considering an average round-trip length of about 50 km (about 31 miles) per day\textsuperscript{92} and
an average mileage of 10 km per liter at a fuel price of 1.7 pesos per liter\textsuperscript{93}, the cost of
driving was assumed to be 0.175 pesos per kilometer in 1994. This value was multiplied
by the distance between origin-destination pairs to obtain the generalized trip costs. The
trip cost represented only the monetary cost of driving a private vehicle into the central
distritos of the DF, thus the value of travel time and other out-of-pocket costs such as
parking charges were not included. Although taxis are actually more expensive for a
traveler than driving a personal car, for the purpose of this analysis, cars and taxis were
assumed to have the same cost for all trips. This is a reasonable assumption considering
that any extra costs due to a congestion charge could be transferred to taxi passengers just
as car owners bear extra costs. This is, of course, not necessarily the case and depends on
the particular design of the congestion pricing scheme.

In London, taxi drivers are exempt from paying the congestion charge because they are
considered to offer a public transport service. However, in the context of Mexico City
where the taxis are responsible for much of the traffic congestion in the city center, an
exemption would only increase the number of taxis in operation. Also, the aim of this
analysis is to show the impact of a change in cost (an increase due to a congestion
charge) on trips made by taxis and cars. Thus, the original value of cost considered for
taxis and cars will not make any difference.

\textsuperscript{92} Average trip length was 55 km in the United States in the year 2000 and 39 km in western Europe (see
Hanson, metropolitan expansion). A few Mexicans who were interviewed said they drove 40-50 km in a
day on average. Thus 50 km was considered a conservative value to start with.

\textsuperscript{93} The current gas price of 7 pesos per liter was deflated to 1994 values using the CPI data for Mexico to
estimate this value. Different sources showed values ranging from 1.4 to 1.7 pesos per liter. However, since
this value will be constant, it does not result in any change in the analysis results.
The data for per capita income were only available aggregated at the *delegacion* level for the DF and the municipality level for the EM. The aggregated values were used to determine approximate income in the *distrito* or municipality where the trip began. The same analysis would have been more accurate if done with household income data disaggregated at the level of the O-D survey; however, due to time constraints, the aggregate values were used as a proxy for per capita income data in each zone. Average trip duration for trips made by car between the O-D pairs was available, and was considered to be the same for both cars and taxis.

5.3. Results of Regression Analyses

The discussion in this section is based on two components of the regression results. The first component comprises the correlations between various variables, showing the strength of the relationship between them. These are zero-order correlations, which means that they take into account the effect of the other variables. The second component consists of the beta coefficients showing the impact of change in the dependent variable (private mode share) for a unit change in the independent variable, what can be called the elasticity.

We run the first regression on trips made from all origins in the MCMA to the 21 central *distritos* forming the assumed ‘congestion zone’. The results are shown in Table 5-2. The three factors, trip duration, trip cost and per capita income, explained the variance in private mode share only moderately, by 44% ($R^2=0.44$, 99% confidence). The resultant beta coefficients show that the factor affecting private mode shares most was trip duration. The aggregate per capita income of the origin *distrito* was relatively less important in predicting private mode share, and the generalized trip cost was least important. We can thus infer that the cost of time spent by travelers in traffic is considered higher than the variable monetary cost of driving or using a taxi.
TABLE 5-2  Regression Results for Trips from All Origins to Central Distritos

<table>
<thead>
<tr>
<th>REGRESSION ON</th>
<th>VARIABLES</th>
<th>Correlations and Descriptives</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>All origins to central distritos</td>
<td>DURATION</td>
<td>0.608</td>
<td>0.616</td>
</tr>
<tr>
<td></td>
<td>COST</td>
<td>-0.220</td>
<td>-0.006 *</td>
</tr>
<tr>
<td></td>
<td>INCOME</td>
<td>0.211</td>
<td>-0.052 *</td>
</tr>
<tr>
<td>No. of observations = 2219</td>
<td>Mean</td>
<td>0.29</td>
<td>27.76</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.33</td>
<td>30.01</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Dependent variable: PRIVATE
Independent variables: DURATION, COST, INCOME
* Correlation or beta coefficient is not significant

The analysis shows that travelers whose trips would take longer were more likely to use private modes. We also see that the trip duration does not relate with the distance between an origin and destination pair and can therefore be assumed to be dependent on other conditions directly affected by traffic congestion, such as traffic speed. We know that trip duration is dependent on factors other than distance because the correlation between duration and trip cost is not statistically significant. There is negligible correlation between them, and this is evident in all the regression results shown in this section. Since the trip cost in all cases is directly proportional to the distance and is derived by multiplying the distance by a constant fuel mileage factor, it can be concluded that the trip duration has no significant correlation with distance in this data set.

A glance at the data shows that even O-D pairs with short distances between them have long trip durations if either the origin or destination or both are located in the central areas of the DF that are known to be very congested. Congestion is thus responsible for higher private mode shares as it makes trip durations longer.

However, the three factors - income at origin, trip duration and trip cost, still leave about 56% of the variance in private mode shares unexplained if we consider trips from all origins to the central distritos. This variance may depend on other factors such as availability of public transport at the origin, geographical segregation between low income and high-income residential areas, and so on.
One indication of this is the correlation between income per capita and trip cost as seen in the table above. The correlation coefficient between them is statistically significant (p-value < 0.01) and equal to –0.437. This shows that as income at the origin decreases, the trip cost increases. Since trip cost is directly proportional to distance, it implies that the trip cost is higher for low income origins that are farther away from the central areas of the DF. To capture the effects of some of the other factors, several regressions were performed on data selected according to particular criteria. The difference in correlation and R² values indicated the added or reduced impact of particular criteria.

**TABLE 5-3  Regression Results for Trips to Central Distritos from Origins in the Estado de Mexico (EM) and from Origins in the Distrito Federal (DF)**

<table>
<thead>
<tr>
<th>REGRESSION ON VARIABLES</th>
<th>Correlations and Descriptives</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
</table>
| Trips from origins in the EM | DURATION 0.736  
(low accessibility to public transport) |  
COST -0.131  
INCOME 0.280  
Mean 0.23  
Std. Deviation 0.34 | Beta 0.711  
t-ratio 31.247  
Sig. p < 0.01 |
| No. of observations = 822 | 13732.19 | Standard Error 0.221 |

| Trips from origins in the DF | DURATION 0.522  
(high accessibility to public transport) |  
COST -0.197  
INCOME 0.176  
Mean 0.33  
Std. Deviation 0.32 | Beta 0.548  
t-ratio 25.144  
Sig. p < 0.01 |
| No. of observations = 1397 | 45957.20 | Standard Error 0.258 |

Dependent variable: PRIVATE  
Independent variables: DURATION, COST, INCOME  
* Correlation or beta coefficient is not significant

In the next step, we repeat the same regression on two sets of O-D pairs, one with all origins in the EM and the other with all origins in the DF. For this, a dummy variable was created that took the value 1 if a trip origin was located in the DF, and 0 if it was not. The results in Table 5-3 show that the EM municipalities are typically not well served by public transport, while the DF distritos have high accessibility to public transport. We find that the three variables, trip duration, trip cost, and income at origin, explain the private transport mode share much better for EM origins, and worse for DF origins, than in the previous analysis when all origins were considered.
For the EM origins, the three factors explained 58% of the variance in private mode share ($R^2=0.58$, 99% confidence). In case of the EM, private mode share is more strongly correlated with trip duration and per capita income than in case of the DF. Since people from the EM have to travel longer distances than those in the DF to the central areas, it is intuitive that their choice of mode would depend more on the time it takes to make the trip. The DF also has a more homogeneous income profile than the EM. Therefore, the use of cars depends more on per capita income in the EM than in the DF. Trip cost, on the other hand, shows a weaker correlation with private mode share in the EM than in the DF, and the beta coefficient for it is not significant. This is important because it shows that demand for private transport in the EM is inelastic with respect to trip cost, and can be explained by the relative absence of better transport alternatives.

Another reason for a weaker correlation with trip cost (-0.191) is that trip cost is proportional to distance and the EM municipalities are all similarly distant from the city center, whereas within the DF, those living nearer to the central areas have higher incomes than those living farther away, as seen from the higher negative correlation (-0.436) between income and trip cost in the DF distritos. The trip duration and trip cost are again not significantly correlated, showing that trip duration depends on conditions other than distance, such as low traffic speed, poor infrastructure, and travel delays.

TABLE 5-4 Regression Results for Trips to Central Distritos from Origins with High Public Transport Demand

<table>
<thead>
<tr>
<th>REGRESSION ON VARIABLES</th>
<th>Correlations and Descriptives</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>DURATION</td>
<td>PRIVATE DURATION COST INCOME</td>
<td>Beta t-ratio Sig.</td>
</tr>
<tr>
<td>mean</td>
<td>0.04</td>
<td>12.33 1.11 27604.37</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.08</td>
<td>24.32 0.60 35139.89</td>
</tr>
</tbody>
</table>

Dependent variable: PRIVATE
Independent variables: DURATION, COST, INCOME
Only those cases selected where PRIVATE <0.25, implying public transport mode share >0.75
* Correlation or beta coefficient is not significant

The next idea we studied is what governs private travel demand in those areas of the city that have good accessibility to public transport, and where many more people use public transport rather than cars or taxis. For this, a dummy variable was created that took the
value 1 if public transport mode share was greater than 75%, and 0 otherwise. Only those O-D pairs where the dummy variable took the value 1 were considered in the analysis.

On running the regression, it was found that the three independent variables explained 67% of the variance in private mode shares ($R^2=0.67$, 99% confidence) in area where use of public transport was high, showing a stronger relationship than we have seen so far (see Table 5-4). In all such areas, the use of private modes was most highly correlated with trip duration, showing that even if public transport was available, low traffic speeds and travel delays prompted people to use private cars and taxis. The trip cost had a higher correlation than income, showing that the use of private modes depended more on the distance traveled than on the income of the travelers.

These results are important because they indicate that even if the image of the public transport network in Mexico City is improved significantly, as long as travel delays are not reduced, people will continue to use private modes, especially those living farther from the city center. The results from the O-D survey showed that while the average journey time in Mexico City was 46 minutes for all modes, it was 35 minutes for trips made by cars only, and 50 minutes for trips made by public transport only. In Mexico City, about 80% of all trips occupied road space (all combinations of trips, except ‘metro only’ trips), with over 60% of total trips made on road-based public transport. It is thus clear that one of the main maladies affecting public transport trips in the city is the delay caused due to congestion. Improving public transport is still not the answer to reducing congestion in the city; rather, it is essential to recognize the finite capacity of available infrastructure, and explore alternative means for enhancing mobility.

These results summarize how particular factors such as driving cost, per capita income, journey time, and availability of public transport affect the use of private transport to travel to the central areas in Mexico City. In the following section, estimates of the potential reduction in automobile trips to the city center and in resulting emissions are

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94 Connolly (1999)
calculated. These estimates are based on different values of the demand elasticity and congestion charge.

5.4. Results of Sensitivity Analyses

The regression results above explain the relationships between various factors and their impact on mode share of private transport for all trips made to the central distritos of the Federal District in the MCMA.

In this section, we will focus on illustrating how the number of automobile trips would be reduced if a zonal congestion charge were applied to the central distritos roughly bounded by the Circuito Interior. The reduction in trips depends upon the demand elasticity with respect to price (here, trip cost) in the metropolitan area. The demand elasticity is defined here as the percentage change in trips caused by a 1% change in the trip cost. The elasticity will differ between sub-groups of the population based on their income. It is usually higher for people with lower incomes since they are more sensitive to an increase in price, and are more likely to change their behavior if extra costs are imposed.

The demand elasticity will also differ based on the purpose of the trip. Trips for work and study purposes are typically less elastic than trips for shopping, recreation or similar purposes. This is because the common traveler response to an increased trip cost is to cut down on trips that are not absolutely necessary. People would only make those automobile trips that they value highly. Peak hour trips in dense urban areas are less elastic with respect to trip costs and congestion delays because these trips are essential, usually to or from work. For the same reason, travel demand elasticities for weekends and weekdays are also usually different.

Elasticities thus usually take several possible values, depending on the type of market, type of consumer and time period. For example, an elasticity value of car trips with respect to trip cost equal to –0.3, would actually vary between –0.1 and –0.6 depending

---

on the type of trip (commercial, commute, recreational, etc.), the type of motorist (rich, poor, young, old, etc.), travel conditions (suburban, urban, peak, off-peak), and the time period being considered (short, medium or long-term).  

Automobile travel demand is believed to be inelastic with respect to most individual price components of driving such as fuel cost, parking charges, tolls, congestion charges, and so on, because they each represent a small portion of total user costs. For example, if the price of fuel is 20% of the total cost of driving, parking or congestion charges are 30%, time delays are 40% and maintenance costs are 10% of total driving costs, then a -0.2 elasticity of driving with respect to congestion costs actually represents an elasticity of -0.67 with respect to total cost of driving. In addition, short-term elasticities that represent changes in demand within a two-year period of implementation of a policy are typically one-third of long-term demand elasticities observed 15 years or more after. Long-term elasticity values are always higher because people consider the effects of prices in taking longer term decisions, and there are always more alternatives they can explore.

We will estimate the reduction in trips due to a congestion charge for an acceptable range of demand elasticities. The elasticity values are considered for the short-term, and they illustrate the change in automobile trips and emissions for different sections of the population. Low income people are more price sensitive than high-income people, and thus their travel demand is typically more elastic. The common range of demand elasticities for a large urban area is between –0.1 to –0.6, and a congestion charge can be considered similar to any access toll commonly implemented. It has been found that people’s travel behavior is more likely to change if the cost per car trip is increased, such as in case of a toll or congestion charge, than if fuel prices or parking costs are increased.

For example, the elasticity value for Seoul, Korea with respect to toll prices is –0.45[^98], and is higher than the elasticity with respect to fuel price. In another study done in Costa

[^97]: Ibid.
 Rica\textsuperscript{99}, the average demand elasticity with respect to an increase in cost per car trip was higher than that with respect to parking cost. Both these elasticity values, however, were lower than the elasticity with respect to increase in automobile travel time. This shows that more trips are restrained by delays caused due to congested travel conditions than by an increased cost per car trip.

Congestion charging is considered a viable policy only for areas where travel demand is relatively elastic because only then is a perceptible reduction in traffic achieved. For example, in London, before congestion charging was introduced, demand was considered less elastic than it actually was. With a charge of £5, it was predicted that there would be a 15% reduction in traffic coming into Central London, but the resulting reduction after six months of introduction of the charge was 30%. Actual demand was far more elastic, because over half the 30% of motorists who stopped driving in the charging hours switched to public transport\textsuperscript{100}.

In Singapore, the demand elasticity with respect to the congestion tolls lies between –0.19 to –0.58, with an average of –0.34\textsuperscript{101}. This value is lower than expected, considering the travel alternatives provided by the excellent public transportation system in Singapore. However, the value is low because the high car ownership taxes allow only higher income people to own cars, and these travelers are less sensitive to a price increase. This situation is similar in Mexico City where more middle and higher income people own cars. In fact, a similar value of –0.36\textsuperscript{102} has been estimated for Mexico City using data from the 1994 O-D survey. One might be lower to some extent today.

A sensitivity analysis was done for Mexico City using different values of demand elasticity to calculate the reduction in trips for different values of a central city congestion charge. Consistent with the assumptions in the regression analysis carried out earlier (see

\textsuperscript{101} Victoria Transport Policy Institute (VTPI)
\textsuperscript{102} A gravity model using data from the 1994 O-D survey estimated the ‘friction parameter’ to be equal to –0.363. This can be considered analogous to demand elasticity because it means that if the cost or distance between an origin and destination increased, the total number of trips made between the two zones would reduce by a multiple of the friction parameter. From Sussman and Gamas-Buentello (2004), draft paper.
Assumptions, section 4.2.), the cost of driving in 2004 was calculated for an average round-trip length of about 50 km (about 31 miles) per day and an average mileage of 10 km per liter at a fuel price of 7 pesos per liter, the cost of driving was assumed to be 17.5 pesos per trip. We added to that an average parking cost of 18 pesos per hour\textsuperscript{103}. The O-D survey showed that the average duration of parking was 5 hours, hence adding 18*5=90 pesos for parking, we get an average trip cost to the central areas to be 107.5 pesos. This was the base value of cost considered for the calculations below, and is a conservatively high estimate. A lower base value would only lead to a higher expected reduction in traffic.

Using the O-D survey data, we know that the total number of daily car trips to the 21 central distritos was 752,638 in 1994. The Ministry of Transportation (Molina, et al 2002) predicts a 25% increase in daily car trips by the year 2020, with all other mode shares held constant. A time series regression performed on these data allows us to estimate that at present, i.e. in 2004, the number of car trips to the central distritos must be 825,007, assuming an approximated linear growth in number of trips over the years. This is the base value of trips used for the calculations in the sensitivity analysis.

**Table 5-5** Percentage Reduction in Car and Taxi Traffic to Central Distritos, Based on Different Demand Elasticity and Congestion Charge Values

<table>
<thead>
<tr>
<th>Elasticity</th>
<th>Value of Congestion Charge in Mexican Pesos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>-0.5</td>
<td>14.0%</td>
</tr>
<tr>
<td>-0.45</td>
<td>12.6%</td>
</tr>
<tr>
<td>-0.4</td>
<td>11.2%</td>
</tr>
<tr>
<td>-0.35</td>
<td>9.8%</td>
</tr>
<tr>
<td>-0.3</td>
<td>8.4%</td>
</tr>
<tr>
<td>-0.25</td>
<td>7.0%</td>
</tr>
<tr>
<td>-0.2</td>
<td>5.6%</td>
</tr>
<tr>
<td>-0.15</td>
<td>4.2%</td>
</tr>
<tr>
<td>-0.1</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

The calculated reduction in car trips is shown above for different values of demand elasticity, considering a plausible range of congestion charge between 30 and 80 Mexican pesos.

\textsuperscript{103} Source: Alejandro Villegas – parking charges in the MCMA vary from 10-25 pesos per hour, with the higher end of the range fixed for the major commercial centers in the DF, including the central distritos.
Pesos (US $3-$8). It is evident that the reduction in trips is less for the higher income groups having lower price sensitivity, and the reduction in trips is more for the lower income groups with higher price sensitivity. Thus, we can further subdivide the range of plausible elasticity values into lowest income group (-0.5 to –0.4), middle income group (-0.35 to –0.25) and highest income group (-0.2 to –0.1). This subdivision is useful because it will help assess if congestion pricing in the area-based form we are considering will be a progressive policy or not.

**TABLE 5-6  Distribution of Households and Car Ownership in the MCMA by Income (2001)**

<table>
<thead>
<tr>
<th>Income Group</th>
<th>All Households</th>
<th>Car Owning Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1,420,105</td>
<td>37.22%</td>
</tr>
<tr>
<td>Middle</td>
<td>1,858,573</td>
<td>48.71%</td>
</tr>
<tr>
<td>High</td>
<td>536,540</td>
<td>14.06%</td>
</tr>
<tr>
<td>Total</td>
<td>3,815,218</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Minimum Wage in 2000 = 35.23 MXP

Assumptions:
- Low Income = Up to 4 times minimum wage
- Middle Income = 5 to 20 times minimum wage
- High Income = Above 20 times minimum wage

Performing the same analysis discussed before, but with calculation of revenues differentiated by income group, we find that the higher income households pay more towards the overall revenues than the middle or lower income households. The policy can therefore, be considered progressive in absolute terms, though it will be regressive at a household level. This is because the MCMA has a majority of households in the middle to low-income category, which would have to pay a larger proportion of household income towards a congestion charge if they continue to drive their cars. The richest car owners represent only 21.5% of all car owning households in the MCMA.

Perhaps the important question to ask is will higher-income people pay the charge and continue to drive anyway? For example, a new toll road in Mexico City, running parallel to the Periferico, has a toll of 80 pesos and is used to only 6% of its capacity, while the Periferico remains highly congested. The problem in this case is that there is an alternative to paying the charge, which is driving on the congested road. People do not
value the time they spend in delays on the Periferico as much as the toll of 80 pesos they would have to pay on the new road. In case of a central city congestion charge however, the alternative to paying the charge would be to use public transport.

The sensitivity analysis shown in Table 5-7 is for a range of congestion charge considered feasible to implement, i.e. from 40 to 60 pesos. The weighted average of revenues and trip reductions is calculated, using the proportion of car owners in each income group as the weights. We find that revenues for a lower charge and higher elasticity are similar to revenues obtained with a higher charge and lower demand elasticity. Even the lowest charge considered, i.e. 40 pesos, would generate average revenues of about 30 million MXP (US $3 million) per day. This translates to substantial annual revenues. It is thus evident that if an area-based pricing scheme could be made to work with political will and appropriate technology, a significant source of new funds could be created for reinvestment in public transport.

### Table 5-7 Daily Revenues and Percentage Reduction in Private Trips, by Income Group and Congestion Charge Value

<table>
<thead>
<tr>
<th>Income Group</th>
<th>Demand Elasticity</th>
<th>Charge 40 Million MXP</th>
<th>Revenue 45 Million MXP</th>
<th>Charge 50 Million MXP</th>
<th>Revenue 55 Million MXP</th>
<th>Charge 60 Million MXP</th>
<th>Revenue 65 Million MXP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>-0.5</td>
<td>18.6%</td>
<td>26.9</td>
<td>20.9%</td>
<td>29.4</td>
<td>23.3%</td>
<td>31.7</td>
</tr>
<tr>
<td>Low</td>
<td>-0.45</td>
<td>16.7%</td>
<td>27.5</td>
<td>18.8%</td>
<td>30.1</td>
<td>20.9%</td>
<td>32.6</td>
</tr>
<tr>
<td>Low</td>
<td>-0.4</td>
<td>14.9%</td>
<td>28.1</td>
<td>16.7%</td>
<td>30.9</td>
<td>18.6%</td>
<td>33.6</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.35</td>
<td>13.0%</td>
<td>28.7</td>
<td>14.7%</td>
<td>31.7</td>
<td>16.3%</td>
<td>34.5</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.3</td>
<td>11.2%</td>
<td>29.3</td>
<td>12.6%</td>
<td>32.5</td>
<td>14.0%</td>
<td>35.5</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.25</td>
<td>9.3%</td>
<td>29.9</td>
<td>10.5%</td>
<td>33.2</td>
<td>11.6%</td>
<td>36.5</td>
</tr>
<tr>
<td>High</td>
<td>-0.2</td>
<td>7.4%</td>
<td>30.5</td>
<td>8.4%</td>
<td>34.0</td>
<td>9.3%</td>
<td>37.4</td>
</tr>
<tr>
<td>High</td>
<td>-0.15</td>
<td>5.6%</td>
<td>31.2</td>
<td>6.3%</td>
<td>34.8</td>
<td>7.0%</td>
<td>38.4</td>
</tr>
<tr>
<td>High</td>
<td>-0.1</td>
<td>3.7%</td>
<td>31.8</td>
<td>4.2%</td>
<td>35.6</td>
<td>4.7%</td>
<td>39.3</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>11.2%</td>
<td>29.3</td>
<td>12.6%</td>
<td>32.5</td>
<td>14.0%</td>
<td>35.5</td>
</tr>
<tr>
<td>Weighted Average</td>
<td></td>
<td>11.4%</td>
<td>29.2</td>
<td>12.8%</td>
<td>32.4</td>
<td>14.2%</td>
<td>35.4</td>
</tr>
</tbody>
</table>

Revenues are shown in Million Mexican Pesos (MXP)

Another value of elasticity to consider is that of demand with respect to travel time savings. Studies show that a majority of motorists are most sensitive to travel time, and that elasticity with respect to travel time is usually the highest. In London, a 30% reduction in the number of car trips to the congestion zone, resulted in a 14% increase in travel time savings in terms of minutes per kilometer due to higher traffic speeds. This
implies that the trip elasticity with respect to travel time savings was \(-1.8^{104}\). For Mexico City, this has been estimated to be \(-0.6\) as a long-term value\(^{105}\). That is, a 6\% reduction in car trips due to a congestion charge would result in an increase in average traffic speed that would cause a 10\% increase in time savings.

The following sensitivity analysis shows the reduction in traffic required in Mexico City for different values of desired increase in average traffic speed. The analysis is based on a demand elasticity value of \(-0.6\) with respect to travel time savings calculated by Eskeland and Feyziglou (1997)\(^{106}\). The numbers are generated for an average traffic speed of 20 km/hr in the central areas of Mexico City\(^{107}\), and an assumed average travel distance of 25 km which is only indicative. We see from Table 5-8 that a reduction in car trips to the city center by 12\% can increase average traffic speed by 5 km/hr, and can reduce travel time by 20\%.

**Table 5-8 Sensitivity Analysis: Demand with respect to Travel Time Savings**

<table>
<thead>
<tr>
<th>Desired increase in average traffic speed (km/hr)</th>
<th>Time savings for 25-km distance (mins.)</th>
<th>Percentage reduction in travel time</th>
<th>Required reduction in trips</th>
<th>Percentage Reduction in car trips required</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>6.82</td>
<td>9.09%</td>
<td>41053</td>
<td>5.45%</td>
</tr>
<tr>
<td>3</td>
<td>9.78</td>
<td>13.04%</td>
<td>58902</td>
<td>7.83%</td>
</tr>
<tr>
<td>4</td>
<td>12.50</td>
<td>16.67%</td>
<td>75264</td>
<td>10.00%</td>
</tr>
<tr>
<td>5</td>
<td>15.00</td>
<td>20.00%</td>
<td>90317</td>
<td>12.00%</td>
</tr>
<tr>
<td>6</td>
<td>17.31</td>
<td>23.08%</td>
<td>104211</td>
<td>13.85%</td>
</tr>
<tr>
<td>8</td>
<td>21.43</td>
<td>28.57%</td>
<td>129024</td>
<td>17.14%</td>
</tr>
<tr>
<td>10</td>
<td>25.00</td>
<td>33.33%</td>
<td>150528</td>
<td>20.00%</td>
</tr>
</tbody>
</table>

Taking this analysis further, we can estimate the reduction in emissions from reduced car and taxi trips to the central *distritos* of the DF. We find that the maximum expected reduction in various pollutants is only a small percentage of the total in the metropolitan area.

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\(^{104}\) Transport for London (2004). *Impacts Monitoring: Second Annual Report* - this was the elasticity value at the boundary of the congestion zone. The extended zone (define) had a much lower elasticity with respect to travel time savings = 0.75 approximately, with a 12.5\% reduction in car trips.


\(^{106}\) Ibid.

\(^{107}\) Villegas-Lopez (2000)
TABLE 5-9   Emissions per vehicle in grams/year/vehicle\textsuperscript{108}

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>No. of Vehicles</th>
<th>NOx</th>
<th>CO</th>
<th>SO2</th>
<th>PM10</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private autos</td>
<td>2,341,731</td>
<td>20,233</td>
<td>351,226</td>
<td>854</td>
<td>299</td>
<td>34,891</td>
</tr>
<tr>
<td>Taxis</td>
<td>109,407</td>
<td>101,392</td>
<td>1,201,504</td>
<td>5,182</td>
<td>1,819</td>
<td>139,936</td>
</tr>
</tbody>
</table>

Source: Gilat (2002)

TABLE 5-10   Emissions Inventory from Mobile Sources in the MCMA, 1998
(Metric tons per year)\textsuperscript{109}

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>No. of Vehicles</th>
<th>NOx</th>
<th>CO</th>
<th>SO2</th>
<th>PM10</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private autos</td>
<td>2,341,731</td>
<td>47,380</td>
<td>822,477</td>
<td>2,000</td>
<td>701</td>
<td>81,705</td>
</tr>
<tr>
<td>Taxis</td>
<td>109,407</td>
<td>11,093</td>
<td>131,453</td>
<td>567</td>
<td>199</td>
<td>15,310</td>
</tr>
<tr>
<td>Combis (colectivos)</td>
<td>5,499</td>
<td>930</td>
<td>20,448</td>
<td>28</td>
<td>10</td>
<td>1,945</td>
</tr>
<tr>
<td>Microbuses (colectivos)</td>
<td>32,029</td>
<td>9,524</td>
<td>216,740</td>
<td>166</td>
<td>59</td>
<td>19,761</td>
</tr>
<tr>
<td>Pick up</td>
<td>336,080</td>
<td>18,961</td>
<td>255,503</td>
<td>522</td>
<td>183</td>
<td>24,599</td>
</tr>
<tr>
<td>Heavy-duty gasoline trucks</td>
<td>154,513</td>
<td>15,297</td>
<td>216,865</td>
<td>240</td>
<td>84</td>
<td>18,683</td>
</tr>
<tr>
<td>Diesel vehicles &lt; 3 tons</td>
<td>4,733</td>
<td>150</td>
<td>249</td>
<td>24</td>
<td>133</td>
<td>168</td>
</tr>
<tr>
<td>Diesel tractor trailers</td>
<td>70,676</td>
<td>22,678</td>
<td>16,675</td>
<td>363</td>
<td>1,990</td>
<td>7,587</td>
</tr>
<tr>
<td>Diesel buses</td>
<td>12,505</td>
<td>11,640</td>
<td>9,270</td>
<td>214</td>
<td>1,174</td>
<td>3,853</td>
</tr>
<tr>
<td>Diesel vehicles &gt; 3 tons</td>
<td>90,940</td>
<td>27,662</td>
<td>20,956</td>
<td>468</td>
<td>2,562</td>
<td>9,205</td>
</tr>
<tr>
<td>Heavy-duty LPG trucks</td>
<td>30,102</td>
<td>308</td>
<td>298</td>
<td>15</td>
<td>16</td>
<td>215</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>72,704</td>
<td>215</td>
<td>22,729</td>
<td>63</td>
<td>22</td>
<td>4,742</td>
</tr>
<tr>
<td>Total Mobile Sources</td>
<td>3,260,919</td>
<td>165,838</td>
<td>1,733,663</td>
<td>4,670</td>
<td>7,133</td>
<td>187,773</td>
</tr>
</tbody>
</table>

Source: CAM (2001)

Since we have considered short-term elasticity values only, we can assume that the calculated reduction in trips to the city center in the morning peak hour occurs in the course of a year. So assuming a base value of daily trips to the central disritos as before, equal to 825,007, and the same values of elasticity considered earlier, we can calculate the emissions saved by the reduction in trips. We also assume that one vehicle makes one trip to the city center per day in the morning peak hours from 7 AM to 10 AM. This again is a reasonable, though conservative estimate. It is equivalent to saying that we have reduced 825,007 vehicles from circulating in the city center by the end of one year of implementation of a congestion charge.

\textsuperscript{108} Molina and Molina (2002)
\textsuperscript{109} Ibid.
The results of the sensitivity analysis are shown below for a congestion charge value of 60 pesos per day. The charge could of course be per trip, but this analysis follows the London model of a daily access charge to the central distritos of the DF. The weighted average amounts of pollutants in tons/year.

**TABLE 5-11 Savings in Emissions based on Demand Elasticity for a 60 Pesos Congestion Charge**

<table>
<thead>
<tr>
<th>Income Group</th>
<th>Demand Elasticity</th>
<th>Charge 60 pesos</th>
<th>Emissions saved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NOx</td>
<td>CO</td>
</tr>
<tr>
<td>Low</td>
<td>-0.5</td>
<td>27.91%</td>
<td>2,746</td>
</tr>
<tr>
<td>Low</td>
<td>-0.45</td>
<td>25.12%</td>
<td>2,472</td>
</tr>
<tr>
<td>Low</td>
<td>-0.4</td>
<td>22.33%</td>
<td>2,197</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.35</td>
<td>19.54%</td>
<td>1,922</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.3</td>
<td>16.74%</td>
<td>1,648</td>
</tr>
<tr>
<td>Medium</td>
<td>-0.25</td>
<td>13.95%</td>
<td>1,373</td>
</tr>
<tr>
<td>High</td>
<td>-0.2</td>
<td>11.16%</td>
<td>1,099</td>
</tr>
<tr>
<td>High</td>
<td>-0.15</td>
<td>8.37%</td>
<td>824</td>
</tr>
<tr>
<td>High</td>
<td>-0.1</td>
<td>5.58%</td>
<td>549</td>
</tr>
</tbody>
</table>

**Weighted Average (tons/year)**  
1,682 | 27,433 | 74  | 26  | 2,790

**Savings in Emissions (%)**  
1.01% | 1.58% | 1.58% | 0.36% | 1.49%

**Maximum savings in emissions (%)**  
1.66% | 2.58% | 2.58% | 0.59% | 2.43%

The results show that the net effect on emissions reduction will be very small relative to emissions in the entire MCMA. However, we need to analyze this more accurately, relative to the emissions in the proposed congestion zone, which are the highest in the MCMA, according to CAM\(^{110}\). The figures on the next page show the highest concentrations of carbon monoxide and hydrocarbons projected for the year 2010 in the central area of the DF. This is the area we have considered as a potential congestion zone.

\(^{110}\) PROAIRE: Programs to Improve Air Quality in the MCMA – 2002-2010
**Figure 5-2** Distribution of CO Emissions in the MCMA projected for 2010

**Figure 5-3** Distribution of HC Emissions in the MCMA projected for 2010

*Source: PROAIRE: Programs to Improve Air Quality in the MCMA – 2002-2010*
Disaggregated data on emissions inventory was not available. However, acknowledging that air pollution is a regional problem, this analysis gives some direction. It shows that congestion pricing is not expected to facilitate significant reduction in overall annual emissions as the proposed ‘congestion zone’ is small relative to the entire metropolitan area. Even in London, overall emissions reduction due to the congestion charging scheme has been low. However, in the central areas, congestion charging would help reduce daily average emissions in the zone, and would reduce the number of days the air quality targets are exceeded in Mexico City.

It must be remembered that a congestion charging policy must specifically be implemented for reducing traffic gridlock, reducing travel delays, and increasing traffic speed. The revenues and emissions reduction can be considered bonus fallouts of the scheme and must be communicated to the stakeholders as such.

The final chapter will present the conclusions of this thesis, along with possibilities for further research.
CHAPTER 6. CONCLUSIONS

The eminent physicist Albert Einstein has said, “The significant problems we face cannot be solved at the same level of thinking we were at when we created them.”

With congestion being an ever-growing problem facilitated by growing car ownership and use, it is clear that we need to think beyond the solutions that have been deployed in previous decades.

At a recent workshop in Mexico City\textsuperscript{111} that brought together government officials, academics, consultants and researchers, the topic of congestion pricing was raised in an open forum. The ensuing discussion showed that there is a considerable lack of understanding about the policy, even among decision-makers. Questions were raised about what a pricing measure should be called and what its emphasis should be, for example, congestion pricing, value pricing, rationing, control of externalities, an argument of fairness in transportation supply rather than efficiency, and so on. The discussion indicated a significant interest in the policy and confirmed the need for research. In this thesis, as a first step, we have examined the major issues that can lead to further inquiries for the local governments to pursue.

A survey carried out in the Mexico City workshop emphasized the importance of institutional coordination for transportation activities, improvements in public transport before applying pricing, and beginning a process of public information. Based on this survey, and a study of other congestion pricing schemes around the world, we recommend a broad strategy for Mexico City, phased as follows:

1) To install parking meters in the central delegaciones of the Federal District (DF) while using the revenues from each delegacion for transport improvements in that delegacion. This is a proposal on the brink of implementation in the same destination area recommended as our ‘congestion zone’. In addition, to begin the process of

\textsuperscript{111} Seventh Annual Workshop of the Integrated Program on Urban, Regional and Global Air Pollution, Mexico City, January 18-21, 2004
public education regarding congestion costs while the new Bus Rapid Transit Corridors are constructed. We note that the installation of parking meters and construction of bus corridors is currently underway in the DF.

2) To engage stakeholders in studying different options for implementing congestion pricing, with due consideration to the costs, benefits, distributive impacts, and use of revenues in each scheme while improving and consolidating vehicle registration records.

3) To consider required institutional changes, such as setting up an implementing authority that would be in charge of executing a pricing scheme when the decision is made in consensus with stakeholders.

To pursue congestion pricing in any form, it is important to first understand the distribution of winners and losers from the policy. The issue of equity is highly political, and one that will directly affect the feasibility of the policy. This is especially so because Mexico City has multiple jurisdictions and decision-making agencies, and each would seek a share of revenues while incurring least costs. This conflict or competition between agencies is bound to undermine any efforts to cooperate. Thus, the first step towards implementation of the phased strategy recommended here must be to ensure institutional coordination between the Federal District (DF) and the State of Mexico (EM).

The survey results showed that government officials are reluctant to implement measures as drastic as congestion pricing before considering options for improving public transport, instituting parking charges, or creating physical restraints, such as pedestrianized streets. Other options such as installing parking meters and issuing penalties for illegal parking, removing taxi and colectivo stations from main streets, regulating the hours of operation of freight traffic, and regulating street vendors, were suggested instead of pricing. These are strategies that are relatively lower in cost, but require authoritative enforcement. We argue that these strategies can be implemented prior to pricing as they facilitate a consciousness about improving traffic congestion; however, a prime cause of congestion is growing use of private cars, and these measures
do not directly solve that problem. The views expressed through the survey are similar to those present in other cities before a congestion charge was introduced.

Most respondents considered improving public transport as the best way to deal with congestion. It is essential to provide reliable public transport alternatives before considering pricing policies, so that lower income households that are priced out of using their cars do not suffer a loss in mobility. On the other hand, the chief mobility choice of lower income households, which is the colectivos, is not likely to change in the short term. While the colectivos do cause congestion, they provide a public transport service too, and suffer from the unreliability and travel delays associated with road congestion. Therefore, a congestion charge will also help public transport, by reducing travel delays on the city’s roads to speed up buses and colectivos.

6.1. Estimated Impacts

To understand the potential impacts of an area-based congestion charging scheme in the DF, we examined the factors influencing automobile use in the MCMA, with some estimates of reduction in traffic and emissions. Chapter 5 describes the results of the analysis. However, it is important to remember that the analysis is only illustrative since it uses data from 1994, which is too old to base current policy decisions on. Yet, we expect that the conclusions resulting from it will not change significantly, and that they would only become more strongly corroborated through current data.

We found that for trips made in the morning peak, the use of private cars is most dependent on the average trip duration. Trip duration, in turn is strongly affected by travel delays rather than the distance traveled. In spite of the fact that areas in the EM are farther from the central city and thus the trip cost for them would be higher, trip cost does not affect use of private cars in the EM. Private travel demand in the EM is less elastic than in the DF because of the fewer public transport options there. It was also observed that in the EM, the use of cars is more strongly correlated with household income than in the DF, possible because of the higher number of lower income people residing there.
From the regression coefficients, the approximate average elasticity value for travel demand with respect to trip cost was found to be \(-0.136\), which is rather low, but not surprising given the disparity in access to public transport in the EM and the DF. Overall, the regression results showed that reducing travel delays for public transport modes such as *colectivos* and buses would be a key policy option to reduce car use from origins in the EM, followed by raising private trip costs. Congestion pricing will work in both these directions, and is thus worthwhile to consider.

As regards the equity issues, a regression performed on those origin-destination pairs where public transport availability and use was significant, confirmed that household income did not play a role in automobile travel demand in those areas. The elasticity with respect to trip cost was also higher, and the correlation with trip duration was stronger. This confirmed that improving public transport would make congestion pricing more viable. However, efforts at initial surveying and modeling, and achieving stakeholder buy-in for congestion pricing are expected to take considerable time. Therefore, plans to enhance the image and services of public transport while communicating the motivations behind congestion pricing must occur side by side as part of an integrated transport strategy.

### 6.2. Recommendations for Further Research

The area-based charging option we examined in this thesis is of course, only one way to apply congestion pricing. The outer ring road, the Periferico in Mexico City, is already highly congested, and thus, a congestion zone that is bound only by the inner ring road may not necessarily serve the purpose. We mentioned in chapter 3 that after the short-term impacts of a central city congestion charge are experienced, the next stage could involve facility pricing on major roads leading to the city center, or expansion of the zone to include the outer ring road, the Periferico.

In London, the central London congestion charging scheme began in a zone that covers about 1% of the Greater London area, with about 200,000 vehicles driving in per day before the charge was introduced. The zone we have described for Mexico City covers
about 2.5% of the Mexico City Metropolitan Area, with a projected 825,000 vehicles driving into the selected zone per day. The London scheme is considered the largest congestion charging operation in the world today. Thus, the charging option described here would in itself involve significant effort.

In addition to area-based charging, other pricing options that can be investigated further for the MCMA are:

- A flat increase in parking charges in congested central areas
- Peak hour pricing in certain congested central zones
- Increased parking charges only in peak hours
- Tolling on Insurgentes Avenue – a key approach into the central city that will benefit from the Bus Rapid Corridor.
- Charging differentially with discounts by income level (based on tax returns, expenditure level, and so on) would be a more sophisticated approach, however, it is recommended that a relatively simpler system be established first.

For further research on congestion pricing in the MCMA it is imperative that a new origin-destination survey be done in order to ascertain the current mobility scenario. It would facilitate more accurate network modeling and data analysis. In addition, a rigorous process of communication with all stakeholders must begin, so that the above different solutions to the congestion problem can be investigated. Surveying the concerns of different population groups, designing the incentives or disincentives they might receive as part of congestion pricing measures, and negotiating between them, are key topics of research in themselves, without which no pricing policy should be implemented.

In addition, a regulatory measure in the form of the no-drive days already exists in Mexico City through the Hoy No Circula program\(^\text{112}\) started in 1989. Presumably, car owners in the middle and upper income classes may be more amenable to congestion pricing if it replaced the no-drive days because it would provide the choice to pay and drive. Since the higher income car owners are a lot more numerous, they may support the

\(^{112}\) See Chapter 4, section 4.3
policy if it substituted the Hoy No Circula. It is a line of reasoning not explored in this thesis, but one that can be studied further.

6.3. Concerns Regarding Implementation

In this research, we have done an initial study of relevant issues; yet, there are many questions we need to answer before planning implementation of congestion pricing in the MCMA. Some of these are as follows:

- How high must a charge be set to see a perceptible decrease in traffic congestion? What is the most effective type of scheme and how would the monitoring and charge collection technology be deployed?

- Considering a timeline of actions, such as Metro expansions, construction of bus corridors, restructuring of colectivo services, and so on, when is the best time to introduce congestion pricing? How would the policy be sequenced along with other measures?

- What steps can be taken to be well prepared for the problems encountered when a congestion charging scheme is introduced? For example, in the area-based scheme recommended here, congestion may shift to parts outside the zone. Public resistance, protests by colectivo operators and businesses may be other negative results that must be considered.

As more groups of stakeholders are engaged, their conflicting interests would create more questions that need to be resolved. The major stakeholder groups would likely include the following:

- Public sector agencies – COMETRAVI, SETRAVI, SCT, who would be responsible for the administrative, operational and enforcement costs, as well as allocation of the revenues to various activities
- Taxi and colectivo operators, who would face an increase in operational expenses
- All car owners, who would face increased trip costs
- Public transport riders, who would benefit from improvements in infrastructure, and from the hypothecation of revenues to investments in public transport
- Truck drivers and freight operators, who would face increased business costs
- Retail establishments and vendors in the DF, who would likely see reduced sales due to less recreational trips made by people
- Residents in the congestion zone considered, as they would frequently make trips in and out of the zone

There are many challenges that must be addressed before implementing congestion pricing in the Mexican context. In Mexico City, public perception regarding corruption in government is high, with a prevalent distrust of government motives. This is a major problem to overcome and is best tackled through extensive public information regarding the potential costs and benefits of pricing. A key lesson learned from many congestion pricing projects is that the rationale behind the policy must be communicated well to the public to ensure support. In addition, the system of decision-making as well as operations must be completely transparent. Decisions regarding the provision of alternative services, allocation of revenues, mitigation, and enforcement, must be made through negotiations between different interest groups, and only then must the proposal be communicated to the public.

It is essential to know what percentage of low-income households in Mexico City own and use cars. Once this is determined, then different options to deal with the equity issue can be considered. There are various options for doing this, such as discounts based on income level, improvements in public transport, discounts on the particular roads or accesses that the majority of low-income people use, or progressively increasing charges for people owning two or more cars. The discounts have to be carefully structured because a congestion pricing scheme would be successful only if more people do not drive. Some believe that many low-income car drivers actually drive their employers’ cars, and thus would not directly bear the burden of a congestion charge. Therefore, data on who in fact accesses the city center, and for what purpose, is a necessary input to the design of any pricing scheme for the MCMA.
While modeling efforts are underway to assess the impacts on trips and mode shares, models usually are based on the assumption that all trips that would be priced out by a congestion charge would be redistributed in public transport. But there would be many trips that are altogether suppressed and cannot be made any more. These raise an important equity concern, yet would not be accounted for. It is necessary to also determine the current demand elasticity with respect to cost per trip in the MCMA, for which an elasticity study must be done.

Another challenge is the fact that vehicle registration databases in Mexico City are unreliable, and are separate for the DF and the EM. This is bound to limit the technology choices that can be applied, and to make implementation difficult. An updated and unified registration database must be created before considering congestion pricing, as the mode of payment and charge collection will depend on it a great deal.

The question of how to deal with the colectivos is important. In this thesis, we suggest that the colectivos be given discounts to acknowledge the public transport service they provide, while considering that they also cause much of the air pollution and congestion. While the proposed Bus Rapid Transit corridors are expected to replace the colectivos that run on those routes, it is essential to reorganize the colectivo services so they act as feeders to the metro and BRT systems. One strategy could be to discount the colectivo operators only if they agree to cooperate in these reorganizing efforts.

We have mentioned earlier that different measures must be carefully sequenced as part of a package of options, which will include congestion pricing, public transport investments, and infrastructure improvements. In the particular case of Mexico City, road construction would need to be a part of these measures not to expand capacity, but because there are missing links in the network. The measures must be sequenced such that the benefits of most improvements are apparent before proposals for congestion pricing are publicly discussed.
On studying the key factors of success in schemes around the world, we find that it will be important to identify a high-profile project “champion”, who would likely be a prominent citizen. Such a person would be necessary to retain on-going dialogue with stakeholder groups, to raise awareness of the benefits of congestion pricing and lessons learned from existing schemes, to highlight proposals for public transport improvements made with the revenues, and to frame proposals in a manner that facilitates public acceptance.

The issues discussed in this thesis suggest that it could take a few years to garner support for congestion charging in Mexico City among all stakeholder groups. The design of the policy would be a less complicated task. The process of changing the mentality of car users so that they accept the costs of using private vehicles in congested areas, of engaging all stakeholders, of arriving at consensus among the different institutional bodies, building public support, and implementing congestion pricing in carefully sequenced phases along with public transport investments, is bound to take time. However, with a current vehicle fleet of about 3.5 million and with a current average annual growth rate of 7%, the number of vehicles will double in Mexico City in ten years’ time. Thus, serious planning for congestion pricing, with complementary measures must begin now.

6.4. Final Word

The aim of this thesis is to illustrate how congestion pricing may be applicable in the Mexico City Metropolitan Area, and to discuss the major issues surrounding the policy. Recognizing that congestion pricing must be part of an integrated transportation strategy, we hope that this work will be the beginning of further research and dialog regarding pricing measures to manage travel demand in Mexico City. Once more recent data becomes available, the sensitivity analysis presented in this thesis can serve as a model for estimating potential impacts of different types of congestion pricing schemes. Finally, the author hopes that this thesis prompts decision-makers to consider congestion pricing as a possible measure in their long-term transportation plans for Mexico City.
APPENDIX 1: SURVEY QUESTIONNAIRE

BRIEF RESEARCH SURVEY

Your Organization: ________________________________

Congestion Pricing – objectives

- Method to manage demand, and allocate road space efficiently between different modes by charging a fee.
- Improves utilization of parking capacity to reduce need for large investments (such as Segundo Piso)
- Implies that people pay a fee to reflect the “true costs” of car use in congested urban areas. These include: time delays due to congestion, pollution, fuel costs, road accidents, road maintenance and operation costs
- Increases efficiency of public transport (buses)
- Raises revenues and can reduce fiscal deficit

Questions

1) Are you familiar with the concept of “congestion pricing”?  
Yes _______ No _______ Not Completely _______

2) How serious do you consider the problem of traffic congestion in Mexico City today?  
Still not a problem _______ Reasonable problem _______ Problem in a critical stage _______

3) How closely is it linked to the air quality problem in your opinion?  
Not related _______ Somewhat related _______ Directly related _______

4) Traffic congestion can be managed by many policy options. Which of the following do you think is the best way to deal with congestion in Mexico City? Please rank options (1 to 5, 1 is most important).
   A - Reform parking policies, and introduce higher charges in congested areas
   B - Introduce congestion pricing, applicable either during peak hours or on certain congested city roads
   C - Use traffic bans such as Hoy No Circula or Pico y Placa
   D - Improve public transport, use physical restraints such as bus-only lanes and pedestrian zones
   E - Expand infrastructure and increase road capacity
   F - Must be a combination of all five above

5) Which of the following do you think will be best for raising revenues? Please rank options from 1 to 5.
   Option A _______ Option B _______ Option C _______ Option D _______ Option E _______

6) Which of the following do you think will be most acceptable to people? Please rank options from 1 to 5.
   Option A _______ Option B _______ Option C _______ Option D _______ Option E _______

7) Who do you think will have the most resistance to a “pricing policy” such as A and B above? Please rank options
   Car owners _______ Colectivo and taxi drivers _______ Freight operators _______ Businesses _______

8) Towards what aspect should the revenues from a pricing policy be directed? Please rank options.
   Road and public transport improvements _______ Tax reductions _______ 
   Improve institutional capacity _______ A fund used for all types of urban development projects _______

9) Which agency should lead efforts in this direction? Please rank options.
   Mayor’s office _______ SETRAVI _______ COMETRAVI _______ SMA _______ CAM _______ All these _______

10) What do you think is the biggest challenge in thinking of such a policy for Mexico City? Please rank options from 1 to 6 (1 being most difficult challenge to overcome)
   Lack of funds _______ Public resistance _______ Fragmented institutions _______ Poor enforcement _______
   Lack of alternatives to driving _______ Vandalism of traffic cameras and other installations _______

Thank you very much for your time. This brief survey is part of a research project at MIT and will be used only for academic purposes. Please direct any questions or comments to Anjali Mahendra, MIT. Email: anjalim@mit.edu
### APPENDIX 2: COMBINED REGRESSION RESULTS

#### Correlations and Descriptives

<table>
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<tr>
<th>REGRESSION ON</th>
<th>VARIABLES</th>
<th>PRIVATE</th>
<th>DURATION</th>
<th>COST</th>
<th>INCOME</th>
<th>Beta</th>
<th>t-ratio</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>All trips to central districts</td>
<td>DURATION</td>
<td>0.608</td>
<td>-0.220</td>
<td>-0.006</td>
<td>-0.616</td>
<td>38.808</td>
<td>p &lt; 0.01</td>
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<tr>
<td></td>
<td>COST</td>
<td>-0.220</td>
<td>-0.006</td>
<td>-0.037</td>
<td>-0.136</td>
<td>-7.702</td>
<td>p &lt; 0.01</td>
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</tr>
<tr>
<td></td>
<td>INCOME</td>
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<td>-0.037</td>
<td>-0.437</td>
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<td>10.422</td>
<td>p &lt; 0.01</td>
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</tr>
<tr>
<td>Mean</td>
<td>0.29</td>
<td>27.76</td>
<td>0.97</td>
<td>35133.45</td>
<td><strong>Adjusted R² 0.443</strong></td>
<td><strong>p &lt; 0.01</strong></td>
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<tr>
<td>Std. Deviation</td>
<td>0.33</td>
<td>30.01</td>
<td>0.58</td>
<td>41298.98</td>
<td>Standard Error 0.247</td>
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#### Correlations and Descriptives

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<th>REGRESSION ON</th>
<th>VARIABLES</th>
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<th>DURATION</th>
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<th>INCOME</th>
<th>Beta</th>
<th>t-ratio</th>
<th>Significance</th>
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<tbody>
<tr>
<td>Trips from origins in the EM (low availability of public transport)</td>
<td>DURATION</td>
<td>0.736</td>
<td>-0.131</td>
<td>-0.073</td>
<td>0.711</td>
<td>31.247</td>
<td>p &lt; 0.01</td>
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<td></td>
<td>COST</td>
<td>-0.131</td>
<td>-0.073</td>
<td>-0.191</td>
<td>-0.042</td>
<td>-1.84</td>
<td>p = 0.066</td>
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<tr>
<td></td>
<td>INCOME</td>
<td>-0.073</td>
<td>-0.191</td>
<td>-0.437</td>
<td>0.19</td>
<td>8.222</td>
<td>p &lt; 0.01</td>
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<td>Mean</td>
<td>0.23</td>
<td>28.34</td>
<td>1.38</td>
<td>16738.34</td>
<td><strong>Adjusted R² 0.581</strong></td>
<td><strong>p &lt; 0.01</strong></td>
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<td>Std. Deviation</td>
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<td>37.03</td>
<td>0.59</td>
<td>13732.19</td>
<td>Standard Error 0.221</td>
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#### Correlations and Descriptives

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<th>Beta</th>
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<tr>
<td>Trips from origins in the DF (high availability of public transport)</td>
<td>DURATION</td>
<td>0.522</td>
<td>-0.197</td>
<td>0.053</td>
<td>0.548</td>
<td>25.144</td>
<td>p &lt; 0.01</td>
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<td></td>
<td>COST</td>
<td>-0.197</td>
<td>0.053</td>
<td>-0.436</td>
<td>-0.153</td>
<td>-6.344</td>
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<td>0.053</td>
<td>-0.436</td>
<td>-0.191</td>
<td>0.167</td>
<td>6.908</td>
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<td>Mean</td>
<td>0.33</td>
<td>27.42</td>
<td>0.72</td>
<td>45957.20</td>
<td><strong>Adjusted R² 0.344</strong></td>
<td><strong>p &lt; 0.01</strong></td>
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<tr>
<td>Std. Deviation</td>
<td>0.32</td>
<td>24.98</td>
<td>0.41</td>
<td>47775.77</td>
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#### Correlations and Descriptives

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<td>Trips between O-D pairs with distance &gt;10m</td>
<td>DURATION</td>
<td>0.742</td>
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<td>-0.051</td>
<td>0.725</td>
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<td>-0.705</td>
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<td>0.144</td>
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<td>28.71</td>
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<th>t-ratio</th>
<th>Significance</th>
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<td>Trips from origins having below average income per capita</td>
<td>DURATION</td>
<td>0.640</td>
<td>-0.195</td>
<td>-0.067</td>
<td>0.622</td>
<td>34.505</td>
<td>p &lt; 0.01</td>
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<td>COST</td>
<td>-0.195</td>
<td>-0.067</td>
<td>-0.430</td>
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<th>t-ratio</th>
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<tbody>
<tr>
<td>Trips from origins having above average income per capita</td>
<td>DURATION</td>
<td>0.594</td>
<td>-0.109</td>
<td>0.239</td>
<td>0.662</td>
<td>15.899</td>
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<td>-0.109</td>
<td>0.239</td>
<td>-0.588</td>
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<td>INCOME</td>
<td>0.239</td>
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<td>Mean</td>
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<td>26.129</td>
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<th>t-ratio</th>
<th>Significance</th>
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<tr>
<td>Trips from all origins having high public transport mode share</td>
<td>DURATION</td>
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<td>46.685</td>
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<td>-0.182</td>
<td>-0.380</td>
<td>-0.157</td>
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<td>-0.380</td>
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<td>3.818</td>
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<td>12.33</td>
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APPENDIX 3: LIST OF CORE, INNER, AND OUTER DELEGACIONES IN THE DF

Refer Figure 2-3 for population distribution

**Core**
Cuauhtemoc
Miguel Hidalgo

**Inner**
Azcapotzalco
Benito Juarez
Gustavo A. Madero
Ixtacalco
Venustiano Carranza

**Outer**
Alvarado Obregon
Coyocan
Cuajimalpa
Iztapalapa
Magdalena Contreras
Milpa Alta
Tiahuaac
Tlalpan
Xochimilco
APPENDIX 4: PEOPLE INTERVIEWED

In Mexico:

Marcela Adriana Basurto Acevedo, SETRAVI
Rafael Nunez Bandera, STC (Metro)
José Flores Estrada, STC (Metro)
Prof. Luis Miguel Galindo, UNAM
Prof. José Luisa Lezama, El Colegio de Mexico
Leonardo Martinez, Universidad IberoAmericana
Sergio Sanchez, SEMARNAT
Joel Ahumada Vargas, SETRAVI
Mr. Alejandro Villegas-Lopez, INE-SEMARNAT

In London:

Nick Fairholme, Policy Manager - Congestion Charging, Transport for London
BIBLIOGRAPHY

CHAPTER 1


CHAPTER 2


CHAPTER 3


CHAPTER 4


CHAPTER 5

CAM (Comisión Ambiental Metropolitana) (2001). Programa para Mejorar la Calidad del Aire de la Zona Metropolitana del Valle de Mexico, 2002-2010 (Programs to Improve Air Quality in the Metropolitan Zone of the Valley of Mexico). Mexico.


GENERAL REFERENCES


