

# INSTITUTIONAL PERSPECTIVES ON ROAD PRICING: ESSAYS ON IMPLEMENTATION, RESPONSE, AND ADAPTATION

by

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**Doctor of Philosophy in Urban and Regional Planning**

at the

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

September 2008

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## **SUMMARY**

Road pricing involves charging road users a fee for the external social costs of using private vehicles. These costs typically remain unaccounted for in routine road transport operations and benefit-cost analyses. They include the costs of travel delays for other road users due to congestion, the costs of air pollution and greenhouse gas emissions, and the health costs resulting from exposure to pollutants and road accidents. In spite of strong theoretical foundations dating back to the 1920s, road pricing remains politically difficult to implement for several reasons. These include concerns about equity impacts and the lack of alternatives to the use of private vehicles, lack of public acceptance for the idea of paying a charge for personal mobility, the administrative complexity of implementation, and the uncertain long term economic impacts of the policy. My dissertation focuses on the institutional challenges to implementation of road pricing that have not received adequate attention in literature, through three papers on the following topics.

- 1) Vehicle Restrictions in Four Latin American Cities: Is Congestion Pricing Possible?
- 2) Potential Impacts of Road Pricing on Businesses and Freight Transport: The Case of the Netherlands
- 3) Implications of the London Congestion Charge for Firms in Key Economic Sectors: Influencing Factors, Impacts, and Responses

In Paper 1, I examine the problems related to adopting road pricing in cities of the developing world that are motorizing rapidly. There are very few studies of this policy in the context of the social, economic, and institutional constraints unique to urban areas in developing countries. The cases studied include four Latin American cities where the command-and-control policy of vehicle circulation bans is already in effect for over a decade, in response to environmental and transportation problems. These restrictions have not been able to prevent the growth in car ownership and traffic congestion, creating the need to consider alternative market-based approaches such as road pricing along with complementary investments in urban public transportation.

In Paper 2, I develop a conceptual framework and propositions to examine the impacts of road pricing on businesses. Distance-based road pricing has been proposed for all roads in the Netherlands and will be applicable to all vehicles from the year 2012. I discuss different theoretical frameworks that may be applied to the subject of firm response to road pricing, focusing on the use of institutional theories such as the resource dependency theory. These theories are particularly instructive in understanding how road pricing might affect firm behavior and economic relationships. I use ideas on organizational adaptation from literature on organization theory to understand the factors affecting firm response to road pricing.

In Paper 3, I adapt and apply the conceptual framework developed in Paper 2 by conducting a survey of businesses in diverse economic sectors in London. The survey instrument included questions about how businesses have altered their locations, logistics operations, policies with respect to employees, and customer-supplier relationships in response to the London congestion charging scheme. I study how these changes may have affected their performance and competitiveness. I found that firm characteristics such as sector, size, and location govern the impacts of congestion charging through institutional variables such as bargaining power within the supply chain, reliance on freight transport, and the effect of other regulations. The findings of this paper are valuable for other cities planning the implementation of road pricing. Together, papers 2 and 3 contribute to a better understanding of the impacts of road pricing on businesses and economic activity using an institutional economic approach.

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## ACKNOWLEDGEMENTS

Since I began working on the topic of road pricing at MIT, up to now when I complete this dissertation, developments in the field and worldwide attention to the policy have grown immensely. It has been extremely exciting and motivating to follow recent proposals for implementing the policy in several cities around the world. My hope is that the papers in this dissertation will contribute to improving theory and practice in the field.

This dissertation has been a delight to work on and I owe thanks to many people who made it possible. I have been fortunate in having an excellent committee of distinguished faculty members. First of all, I thank Prof. Ralph Gakenheimer, my advisor at MIT, with whom I have had the pleasure and privilege of working for over six years now. Ralph has been a wonderful mentor and I have learned from him most of what I know as a researcher and practitioner of transportation policy. I am grateful for the constant encouragement and support he has provided. He always had a unique ability to view the big picture of my research and draw my attention to the most significant questions, giving invaluable feedback on all that I wrote.

I am also grateful to Prof. Karen R. Polenske, whose exceptional standards of research and writing have been an inspiration for me in my own work. It was through Karen's classes in regional economic development that I first became interested in regional and urban economics and in broadening the scope of my research in transportation policy. The insights I gained from those classes made me interested in studying the crucial links between freight transportation and the regional economy by way of product supply chains.

I thank Prof. Joseph M. Sussman at MIT's Center for Transportation and Logistics (CTL) for his interest in my topic and his encouragement. I have had some excellent classes with Joe and it was in his class on Intelligent Transportation Systems that I first explored the idea of congestion pricing several years ago. In my time at CTL, I was fortunate to interact with Fred Salvucci whose classes I enjoyed immensely and from whom I learned much about the politics of implementing sustainable transportation policy. In the Department of Urban Studies and Planning where I spent several years, I am grateful to Prof. Larry Vale who personally ensured that I moved along smoothly in the doctoral program, coming to the rescue when I fell short of funding one semester. I enjoyed Prof. Frank Levy's great sense of humor and thank him for the strong grounding in research methods. I also thank Prof. Bish Sanyal for his interest in my work and for our many interesting conversations about India.

My research, conducted across three countries, would not have been possible without the generous support facilitated by Prof. Hugo Priemus of Technische Universiteit (TU) Delft in the Netherlands. I am deeply grateful to Hugo for his faith in fledgling ideas I proposed early in the dissertation process, for his valuable advice throughout the process, and for his commitment to ensuring that I completed the dissertation without any setbacks. Through Hugo, I came into contact with people at TU Delft who provided a research base while I stayed there for two extended periods in 2007. Prof. Bert van Wee in the Transport Policy and Logistics Organization group at the Faculty of Technology, Policy, and Management, was instrumental in the development and early conceptualization of my papers, as well as in giving insightful comments as I neared the end of my work. I learned much from him about maintaining the highest standards of rigor in the research process. I am also grateful to Odette van de Riet and Diana vonk Noordegraaf at TU Delft for valuable brainstorming discussions about my research. My fieldwork in the Netherlands would not have been possible without support from the Dutch Institute of Applied Scientific Research (TNO) and Diana's significant help in organizing and

conducting the interviews. Thanks to Trudie Stoute-van de Garde for making sure I always had all I needed in Delft, and to all the people I interviewed in Rotterdam for their time and interest in my research.

In London, I thank Mark Pragnell at the Center for Economic and Business Research, James Ford at the London Chamber of Commerce and Industry, Nick Winch at the Federation of Small Businesses, and Minakshi Roy at the Confederation of British Industry for their valuable suggestions on my questionnaire. I also thank ComRes for meeting the many demands of an academic in conducting rigorous survey research.

For the work on Latin America, I am grateful to Chris Zegras for providing the initial contacts for conducting my internet survey and to Alvaro Covarrubias for generously volunteering to translate my English questionnaire into Spanish. I also thank all the transportation experts in Mexico City, Santiago de Chile, Bogotá, and São Paulo – particularly, Alejandro Villegas, Arturo Ardila-Gómez, Dario Hidalgo, and Eduardo Vasconcellos – who shared their knowledge and experiences with me. Financial support for my dissertation was provided by the Integrated Program on Urban, Regional and Global Air Pollution at MIT and two Dutch research programs, “Next Generation Infrastructures” and “Innovative Land Use”.

My deepest gratitude is to my family for their unwavering love and support in all ways. This dissertation is dedicated to my beautiful mother Shashi Mahendra, whose strength and wisdom I can only aspire to have, and to the fond memory of my father Balkrishan Mahendra. I thank my brother Mohit, sister Nidhi, and their families for their love, encouragement, and advice throughout my years as a graduate student at MIT. They have always set high standards for me to follow. I am also grateful to my in-laws, Madhava Rao, Bhavani Rao, and Arvind Rao, for their cheerful and unconditional support.

Finally, my heartfelt thanks go to Bala, my husband, for being not only my most loving, wonderful, and supportive friend, but also my best critic and the sounding board for all my ideas – as silly or as profound as they may be. The challenge of completing this dissertation was made easier with his love and patience. I am blessed to share my life with him and I look forward to many exciting experiences and accomplishments with him by my side.

Anjali Mahendra  
August 15, 2008

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## Introduction

Road pricing includes policies aimed at internalizing the costs of traffic congestion, air pollution and greenhouse gas emissions, the costs of travel delays, and the health costs resulting from exposure to pollutants and road accidents. These are the negative externalities arising from the use of private and commercial vehicles that remain unaccounted for in routine road transport operations and benefit-cost analyses. Charging a fee in proportion to the use of roads, especially in already congested areas, is one way to solve the problem of negative externalities. It is akin in principle to pricing practices in other infrastructure sectors, for instance, charging higher rates for using telephone services in peak hours (Wachs, 1995a). Vehicle ownership and registration taxes, dedicated road taxes, income taxes, and tolls that road users typically pay are often used for funding infrastructure construction and maintenance, but not to cover the costs of externalities.

Different categories of road pricing policies have been described in transportation literature depending upon the accuracy with which the policy accounts for the marginal social costs of the use of private vehicles. Policies such as distance-based charging are closest to marginal social cost pricing and are categorized as first-best pricing, while policies such as zone, cordon, or area-based congestion pricing are considered cruder but easier for users to understand. These are especially targeted at congested locations or congested time periods and are categorized as second-best pricing (Arnott & Small, 1994). Parking charges differentiated by time and location are not a form of road pricing because they do not strictly correspond to the amount that a vehicle is used on the roads. However they are often used as a proxy for road pricing in the absence of other pricing measures. In this paper, the term *road pricing* includes charges for vehicle use during peak hours, at congested locations, for environmental emissions, or for payment of infrastructure maintenance costs, with the main criterion being that the price paid corresponds with the amount that a vehicle is used—either in terms of the number of trips or the distance traveled. The term *congestion pricing* generally refers to charges applied for access to congested locations of a city such as downtown areas and particular congested corridors, i.e., charges applied with the explicit objective of congestion mitigation. These form a specific category of road user charges and are included in all references to the term *road pricing* in this paper.

The idea of road pricing has its foundations in early expositions by Pigou (1920) and Knight (1924) on the use of optimal pricing as a solution to manage the external costs of overconsumption of public goods. It was Vickrey (1955) who first wrote, some 30 years later, about applying the theory of marginal cost pricing explicitly to manage the use of roads, especially during peak hours. His ideas, considered radical as he wrote about them from the 50s to the 90s, were ultimately recognized for their relevance when he received the Nobel Prize in Economics in 1996. Since that time, there has been growing worldwide attention to road pricing, especially with the advancement in technologies that enable the policy. However, political feasibility and public acceptability for implementation of the policy remain a problem. In considering the complexity of real world implementation, there are several aspects of the policy that must be better understood if it must result in desirable outcomes. The quote below by Charles Lave (1995) expresses this concern. In his article (Lave, 1994), he diagrammatically shows how road pricing can lead to both winners and losers, to help understand why people don't accept the pricing solution.

*"It has been a commonplace event for transportation economists to put the conventional [congestion cost] diagram on the board, note the self-evident optimality of pricing solutions, and then sit down waiting for the world to adopt this obviously correct solution. Well, we have been waiting for seventy years now, and it's worth asking what are the facets of the problem we have been missing. Why is the world reluctant to do the obvious?"*

Through the papers comprising this dissertation, I search for practical answers to this question by the study of different cases—where road pricing is not yet under consideration, where it has recently been proposed for implementation, and where it has already been implemented. I also search for theoretical answers by employing a different paradigm of analysis, that of institutional analysis, not often used in studies on road pricing. I argue that there is much to be gained by building upon the neo-classical economic foundations of the theory of road pricing through a systematic understanding of institutions and the political process as critical constraints to implementation.

### **Motivations**

There are two key reasons that road pricing is an important policy to study—one is the necessity to manage the external costs associated with the transportation sector, and the second is to examine alternative and fairer means of funding transportation infrastructure. Several environmental challenges of present times such as the increase in global greenhouse gas levels and the problem of climate change, air pollution, and associated public health problems in large

urban areas especially in the developing world, and rising consumption of fossil fuels, all demonstrate the externalities of the transportation sector. In addition, the often unmeasured social and economic cost of lost productivity due to congestion poses an important challenge. On the transportation supply side, these problems may be managed through technological options such as improving the road network and public transportation system, setting fuel efficiency and emissions standards for vehicle engines, and by developing alternative fuels and vehicles that can run on them. On the demand side, these may be managed by regulatory and economic policies that provide incentives for changing travel and fuel consumption behavior, for example driving fewer vehicle miles, driving at non-peak hours of the day, or driving fuel efficient vehicles.

Policy instruments such as road pricing that encourage changes in travel behavior and can result in more efficient use of transportation resources are known as Transportation Demand Management (TDM) measures (VTPI, 2007). Of these, economic instruments such as parking charges and vehicle ownership taxes as well as regulations such as vehicle circulation bans have been adopted more widely because they are simpler to implement than road pricing. Any form of road pricing remains controversial and hence, politically difficult to implement for several reasons. These include concerns about equity in mobility and the lack of alternatives to the use of private vehicles, lack of public acceptance for the idea of paying for personal mobility, the administrative complexity of implementation, practical problems such as privacy issues, and the uncertain longer term economic and land use impacts of the policy.

Although Singapore has had road pricing in effect since 1975, for several of the above reasons, the policy has not been implemented in many regions of the world since then. It is only after a period of about three decades that the recent implementation of congestion pricing in London, a large city with democratic governance, has brought increased attention to the policy. The London case has largely been considered a success and congestion pricing has subsequently been proposed in other cities of the United Kingdom. Since 2003 when congestion pricing was implemented in London, other cities around the world have also proceeded with plans for road pricing including Santiago in 2005, Stockholm in 2007, and most recently, Milan in 2008<sup>1</sup>. In recent months, downtown congestion pricing has been proposed in San Francisco and New

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<sup>1</sup> Information on the cases of implementation of road pricing can be found on <http://www.roadpricing.biz>, a website developed and maintained by Danish research institute, KeyResearch.

York City in the US too. The Netherlands and the United Kingdom are two countries where plans for nationwide road pricing are currently underway.

Therefore, it is only recently that road pricing has begun attracting the attention of policy-makers and practitioners, in spite of the strong theoretical foundations of the policy and substantial support from economists and transportation scholars. Several driving forces have been identified for this “dramatic change in attitudes in the policy climate” (Grieco & Jones, 1994): (1) the intensification of congestion due to growing road-based passenger and freight volumes in industrialized countries, and a recognition that road capacity cannot be expanded indefinitely to solve the problem, particularly in urban areas; (2) global agreements over the last decade that stipulate the adoption of environmentally friendly solutions by the nations of the world, including mechanisms to reduce transport-related greenhouse gas and pollutant emissions; (3) the development of new electronic technologies that ease the adoption of sophisticated TDM measures; (4) the development of a “culture of privatization” focused on financing public goods and services through targeted user fees rather than through general tax revenues, facilitated by new technologies; and (5) the need for alternative sources of funding public infrastructure due to budgetary pressures and declining fuel tax revenues. To these, I add a sixth driving force that is the rapid increase in automobile ownership and traffic congestion induced by economic growth in cities of developing countries that are looking for options to manage their motorization.

***Institutional analysis: An alternative paradigm to study road pricing***

Optimal pricing or taxation of externalities was first proposed as a means to increase social welfare (Pigou, 1920), in the paradigm of neoclassical economics. Accordingly, there is a strong tendency in the literature to adopt rational choice and utility-based models that measure generalized costs and benefits to assess the impacts of such economic policies. However, it is important to note that road pricing is a policy whose objective is to modify traveler behavior through the mechanism of price (increase), similar to other market-based policies applied in other sectors. It follows that a change in behavior would involve a change in institutions, defined here according to North’s definition of institutions as a set of rules, laws, conventions, behavior norms, and their enforcement characteristics (North, 1990, 1994). North (1990) explains that fundamental changes in relative prices are the most important sources of institutional change because they alter the incentives of individuals and organizations.

In fact, Pigou's ideas on the taxation of externalities to force a change in behavior were challenged by Ronald Coase (1960) in his seminal article "The Problem of Social Costs" that discussed the effects on firms. Coase's main point in that article was that the price mechanism can be used to resolve the problems of social costs or externalities in a hypothetical world of zero transaction costs assumed by Pigou and other economists in the neoclassical tradition. However, this may not be the most desirable arrangement in the real world where transaction costs are always positive, especially where an adaptation of institutions is involved. The costs of measuring the multiple valuable dimensions of goods or services exchanged or of the performance of agents, and the costs of enforcing agreements determine transaction costs (North, 1990). Pigovian price theory rules out by assumption "qualitative elements" such as specialized knowledge, organizational relationships, and sharing of information. It interprets all economic activity in terms of price and quantity and whether these are of the right magnitude or not (Langlois, 1998). Coase contended that the Pigovian approach to deal with externalities was in error because it ignored the governmental costs and spillover effects that may result from policies involving taxation, subsidies, or regulations, i.e. those aiming to modify behavior through pricing (Coase 1960). Coase has thus criticized neoclassical economic analysis for its neglect of institutions (Samuels & Medema, 1998).

With his article, Coase gave rise to a new paradigm—that of New Institutional Economics. This was based on the premise that institutions matter because it is always costly to transact. Institutions affect the performance of the economy by their effect on the costs of exchange and production (North, 1990). Although formal laws can rapidly be changed through political decision, individual firms and actors may not perceive, accept or understand these changes immediately. Informal rules take longer to change and may change in a manner that is incompatible with initial objectives, thus leading to unanticipated consequences. I find that several strands of New Institutional Economics (NIE) or, more broadly, institutional theories, apply to the problem of examining road pricing as a solution to the externalities of transportation. But few studies exist that have examined the policy from this theoretical lens before<sup>2</sup>.

Apart from Coase, other scholars who studied the problem of externalities from this perspective were Alchian and Demsetz (1973), through their theory of property rights. They explain how the

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<sup>2</sup> The only study the author is aware of is one that analyzes the impacts of road pricing using the theoretical framework of transaction cost economics in a thesis completed by Vonk Noordegraaf (2007) at TU Delft, based on data collected in collaboration with the author.

right to use roads, a public good, is usually a communal property right. It is the restructuring of property rights from communal rights to purchased private rights managed through a price mechanism that can encourage people to take social costs into account (Alchian and Demsetz, 1973). Understanding congestion as a problem of flawed property rights to the use of a scarce resource illuminates many aspects about why the policy faces low political will for implementation and why it faces opposition from key stakeholders. This again relates to the importance of transaction costs involved in institutional change, that is, in the restructuring or reassignment of these property rights<sup>3</sup>. A relevant question is whether the transaction costs that arise from implementing road pricing are actually higher for society than the current inconveniences from congestion<sup>4</sup>, which can also be considered a transaction cost involved in the process of exchange<sup>5</sup>. Coase advocated adopting such a comparative institutional approach to assessing whether a policy measure is appropriate for a given situation or not (Samuels & Medema, 1998). In the context of organizations such as firms, transaction costs can arise from existing institutional constraints related to the dependencies that firms have on each other and to the balance of power in their relationships. These aspects are discussed thoroughly in the literature on organization theory that is also considered a part of institutional theories (International Society for New Institutional Economics).

Another institutional theory relevant to this discussion is that of institutional path dependence in the adoption of new technologies and new institutions. It implies a resistance to change older, inefficient practices simply because they have been established beforehand. Thinking of road pricing from this perspective, it is worth noting how a prior and more inefficient system of paying for transportation infrastructure through fuel taxes and general taxes is a problem today. Since paying for infrastructure is not linked with the amount that it is used, problems of over-consumption occur in several locations. Additionally, the initial definition and operation of roads as a public good presents a key obstacle to the new idea of paying for their use. The reluctance

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<sup>3</sup> Allen (1998), p. 108) defines transaction costs as the costs of establishing and maintaining property rights. See Allen's article for a clarification of meanings of property rights and transaction costs and the relationships between them.

<sup>4</sup> In focusing on examining the proposed effects of a policy change by assessing whether it would in total be better or worse than the original one, Coase (1960) states:

"It would clearly be desirable if the only actions performed were those in which what was gained was worth more than what was lost. But in choosing between social arrangements within the context of which individual decisions are made, we have to bear in mind that a change in the existing system which will lead to an improvement in some decisions may well lead to a worsening of others. Furthermore we have to take into account the costs involved in operating the various social arrangements (whether it be the working of a market or of a government department), as well as the costs involved in moving to a new system. In devising and choosing between social arrangements we should have regard for the total effect. This, above all, is the change in approach which I am advocating."

<sup>5</sup> Quoting Zelder (1998), "transaction costs capture *any* phenomenon which might generate a conventional market failure." These transaction costs are not explicitly incorporated in models used by welfare economists.



to accept road pricing possibly reflects path dependence, not only on the part of road users but also on the part of governments hesitant to implement a radical change in policy. This is another example of the interesting association of the politics and problems surrounding the implementation of road pricing with institutional theories.

In this dissertation, which comprises three independent papers, I present institutional analyses of road pricing policies in three different contexts. The first paper, “Vehicle Restrictions in Four Latin American Cities: Is Congestion Pricing Possible”, is an exploratory study of the prospects for congestion pricing in four Latin American metropolitan areas—Santiago de Chile, Mexico City, São Paulo, and Bogotá—where traffic bans are currently in effect on one or two days of the week. Despite implementation of restrictions on the use of vehicles—considered a radical idea when first implemented in the 80s and 90s in these cities—the number of vehicles, congestion, and air pollution continue to increase rapidly, making some of these cities look toward more sophisticated forms of managing private travel demand, such as road pricing. In this paper, I emphasize the importance of knowledge about the policy and awareness of its likely costs and benefits in building a political agenda for implementation. The lack of political will is considered the biggest challenge to implementing congestion pricing in these cities and car owners are expected to oppose the policy even if it replaced the driving restrictions. In some cases, the traffic bans, once implemented out of necessity, are now considered useful in managing congestion only because their absence would lead to still more congestion. Through a historical analysis of the implementation process and experience of the traffic bans, along with a snowball-sampled survey of transportation experts in each city, I find that three factors are most important to increase acceptability for implementing congestion pricing in these cities—(1) widespread public information regarding the environmental and health risks of traffic congestion and resulting air pollution; (2) implementation of complementary policies such as public transport enhancements and increased parking fees in congested areas; and (3) development of a knowledge culture among politicians and experts through discourse on alternative road pricing policies based on systematic analysis.

Among other pertinent issues discussed, this research shows that the equity concerns for low-income car drivers often cited in discussions on congestion pricing in developed countries are less applicable in developing country cities. The lack of political will is a key concern because it is people with relatively higher incomes and political influence who predominantly own and use cars in the four cities studied. This can be understood through the theory of path dependence

because those individuals and organizations with more bargaining power as a result of the existing institutional framework have a major stake in perpetuating the system (North, 1994). The findings, though exploratory, are important because the potential of congestion pricing to manage the rapid pace of motorization in the developing world is not well studied. This paper presents an initial step towards studying the implementation of the policy in developing countries.

The second paper, “Potential Impacts of Road Pricing on Businesses and Freight Transport: The Case of the Netherlands”, presents a conceptual framework based on institutional theories, particularly theories of organizational adaptation, to understand how road pricing might potentially affect firms in the Netherlands. The Dutch have proposed among the most sophisticated road pricing policies in the world for implementation in the year 2011, based on the distance traveled on all roads in the country—a scheme as close to marginal cost pricing as is possible. I examine several theoretical frameworks that might facilitate an understanding of the impacts of this road pricing scheme on firms. These include theories from new institutional economics, neoclassical economics, location theory, and supply chain management. Using data from firms located in the Port of Rotterdam region, I then investigate how the implementation of road pricing affects the accessibility, logistics operations, productivity, and competitiveness of firms in different economic sectors, and the institutional mechanisms through which they would respond to the policy. The interdependence of firms on each other and their market power in a supply chain, the institutional environment of regulations and market conditions that they operate in, and the type of road pricing policy, are important factors in the conceptual framework. These institutional factors mediate the effect of firm characteristics such as size, sector, and location in determining the impacts that might be expected on different types of firms. I found pronounced sectoral differences that clearly indicate the limitations of using aggregate freight models to study these impacts, as is often the case.

According to North (1990), economic organizations like a firm come into existence and evolve under the influence of existing institutional conditions, and they in turn, incrementally alter the institutional conditions. Thus, organizations and their entrepreneurs are the agents of, and shape the direction of, institutional change<sup>6</sup>. The responses of firms to road pricing are then, in essence, adaptations by firms to their institutional environment. The literature on organization

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<sup>6</sup> North (1990) clarifies the distinction between institutions and organizations by explaining it in terms of an analogy to sports—just as institutions can be understood as the rules of the game, organizations can be understood as the teams whose objective is to win the game by a combination of skills, strategy, and coordination.

theory offers several insights into organizational adaptation that I use to put forth a set of preliminary propositions about the impacts that different types of businesses might experience due to road pricing.

The third paper is titled “Implications of the London Congestion Charge for Firms in Key Economic Sectors: Influencing Factors, Impacts, and Responses”. In this study, I apply the conceptual framework developed in the second paper to the case of London where congestion pricing was implemented in 2003. Using evidence from a telephone survey of about 400 firms across sectors important in the urban economy, I investigate how the firm characteristics, operations, and the institutional environment of a firm determine the impacts it faces due to congestion charging in London. Although this paper focuses on a different geographical context, the results support some of the propositions advanced in the second paper. They also provide guidance to decision-makers about how congestion pricing may be better planned by considering several under-explored issues. These include the other policies and regulations that businesses and their employees are subject to, the inflationary effects, secondary economic impacts, and accessibility impacts that may be expected in certain sectors, and the dependencies that firms may have on freight transport taking all links in the supply chain into account.

Through the three papers, I show the importance of institutional theories in understanding the complexity and challenges of implementing market-based policies. In practical terms, I show how such institutional analyses prior to implementation can help avoid potential problems in the planning of road pricing policies. This dissertation is relevant for practitioners and theorists considering the merits of market-based policies and their application to specific real-world problems. I end this Introduction with a quote from William Vickrey, often considered the “father of congestion pricing” (VTPI), an economic theorist whose work has had a substantial influence in public policy (Arnott, 1997).

*“...it is perhaps well to state explicitly that in common with any other theoretical principle, the principle of marginal cost pricing is not in practice to be followed absolutely and at all events, but is a principle that is to be followed insofar as this is compatible with other desirable objectives, and from which deviations of greater or lesser magnitude are to be desired when conflicting objectives are considered. On the other hand, I propose to maintain that marginal cost must play a major and even a dominant role in the elaboration of any scheme of rates or prices that seriously pretends to have as a major motive the efficient utilization of available resources and facilities.”*

From “Some Implications of Marginal Cost Pricing for Public Utilities” (Vickrey, 1955)

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## **PAPER 1**

### **Vehicle Restrictions In Four Latin American Cities: Is Congestion Pricing Possible?**

Published as: Mahendra, A. (2008). Vehicle restrictions in four Latin American cities: Is congestion pricing possible? *Transport Reviews*, 28(1), 105-133.

# Vehicle Restrictions In Four Latin American Cities: Is Congestion Pricing Possible?

## 1. Introduction

Economists often consider congestion pricing policies to be more efficient in dealing with urban traffic problems than traffic bans, with the latter having been described as “draconian measures” (Hau, 1993). This is because instead of simply being restricted from driving on a certain time or day, vehicle owners can be given a choice to pay for the use of their vehicle in peak hours or in congested areas under a pricing scheme. Additionally, the revenues raised from charging drivers can be used for a variety of public purposes (May, 1992). When seen in comparison with congestion pricing, command-and-control policies such as vehicle restrictions are considered to be crude measures because they do not account for the differing importance of different types of trips and they lose effectiveness over time, as car ownership increases (Jones and Hervik, 1992). But the implementation of congestion pricing usually faces political problems due to concerns regarding public acceptability and equity (Giuliano, 1992; Wachs, 1995; Button and Verhoef, 1998; Viegas, 2001; Schade and Schlag, 2003). This is the chief reason that pricing policies are in operation in only a small number of urban areas, including Singapore, London, and a recently completed road pricing experiment in Stockholm, Sweden. Here, we consider urban congestion pricing distinct from tolls on specific lanes or corridors as seen in some cities in the US and Canada. It is also considered distinct from road tolls for recovery of infrastructure costs, as seen in Oslo, Trondheim, and Bergen in Norway. This is because it involves paying a charge either to access a congested area or paying in proportion to the usage of roads, and is differentiated by location, time, and other variables such as type of vehicle. In this respect parking charges are not a form of congestion pricing since they do not correspond with road usage though they are often adopted as a proxy for it. Parking charges already exist in some of the most congested areas of the four cities discussed in this study, through the use of parking meters and paid-parking facilities. There is undoubtedly scope to expand these facilities and to increase parking charges as a travel demand management strategy. Without disregarding the benefits of reformed parking policies, in this paper we explore congestion pricing as a promising option not widely discussed in the context of the Latin American cities under study.

After the apparent success of the London Congestion Charging scheme that began operating in 2003, the topic of congestion pricing has received increased attention by scholars and practitioners. Our interest in pursuing this research is to explore prospects for the

replacement of existing traffic restrictions by congestion pricing in four Latin American cities—Santiago de Chile, Mexico City, São Paulo, and Bogotá. In addition, we discuss the views of transportation experts in these cities regarding the applicability of congestion pricing in their specific contexts.

This work is important because the continuing growth of vehicles, traffic congestion, and air pollution in these cities, in spite of the vehicle restrictions, has made it necessary to explore more effective approaches to manage travel demand. The concerns that motivated implementation of the restrictions have only intensified in recent years. Before congestion pricing is discussed more publicly in these cities, it is first important to understand the attitudes of decision-makers and experts to the existing traffic bans. Ison (2000) mentions the scarcity of studies to understand the attitudes of decision-makers towards urban road pricing in the UK even after over three decades of discussion about the policy at the political level. It is understandable that this dearth of studies is much more pronounced for Latin American countries.

While the London Congestion Charging scheme forms an important model for other cities, since London is a high-income city, the lessons from its experience are not directly applicable to cities in developing countries. Any discussion regarding congestion pricing in these cities—indeed even in high-income cities—revolves around the difficulties of implementation. In fact, many transportation experts themselves have divergent views about the feasibility of congestion pricing in their cities. This research reveals some underlying reasons, giving an insight into why such schemes have not yet received attention in developing countries.

## **2. Methodology and Case Selection**

In this paper, we trace the history of the existing traffic bans in Santiago de Chile, Mexico City, São Paulo, and Bogotá and also summarize the results of a survey of transportation experts in the four Latin American cities. The survey included questions concerning perceptions of congestion and options to manage it, opinions about the existing vehicle restrictions, political challenges to implementing congestion pricing, concerns about public acceptability, equity, institutional and administrative problems, and the feasibility of implementation. Together, the historical analysis and survey discussion help answer the question: can we draw insights about implementing congestion pricing from the experience of the traffic bans existing in all cities and what are the views of experts about the policy in each city?

Of the four cases studied, Mexico City and São Paulo are large cities<sup>7</sup>, with metropolitan populations of about 19 million and 18 million respectively. Bogotá and Santiago are medium-sized cities with about 8 million and 6 million people respectively. The average car ownership rate is estimated at about 130 cars per thousand inhabitants in Bogotá, 148 in Santiago, 166 in Mexico City, and 184 in São Paulo<sup>8</sup> (see Table 1). These figures are quite low in comparison with the average figure of 750 for the United States or 729 for the San Francisco Bay Area as an example of a US metropolitan area (MTC 1997). The growth rate of the number of cars in Santiago was about 10.5% per year between 1991 and 2001, 5.5% in São Paulo between 1987 and 1997, about 7% in Mexico City between 1994 and 2004, and 5.5% in Bogotá after 2001.<sup>9</sup> This implies that without any policy interventions, anywhere between 7-12 years, these cities are likely to have double the number of automobiles they have today, despite already having restrictions in place to control automobile use.

#### **TABLE 1 ABOUT HERE**

The four cities selected have common initial conditions for many factors relevant to their transportation context. Santiago de Chile, Mexico City, São Paulo, and Bogotá have heavily used urban transit systems that provide limited access to peripheral areas. All four cities have multiple levels of government authority, high spatial segregation by income, serious pollution concerns, growing car ownership rates, and existing traffic bans. However, these cities differ in their economic growth, absolute income level, size, and other factors. In the task of comparing attitudes within and across four cities, there may be several other factors particular to each city's context that may have not been considered. But the findings presented in the paper represent the views of transportation experts surveyed in each city, and the factors they gave importance to. Through the summarized survey findings, we show how respondents' answers provide inferences regarding the prospects for congestion pricing. We found that expert views in each city varied with the level of knowledge and discussion about the policy, essentially the political and professional 'knowledge culture' with respect to congestion pricing.

This work was based on extensive secondary sources and primary data in the form of structured survey questionnaires, and interviews with key informants. A survey entitled

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<sup>7</sup> Throughout the text, wherever the term "city" or the name of a city is used, it refers to the entire metropolitan area.

<sup>8</sup> Data from SETRAVI (2000) for Mexico City, CMSP (1998) for São Paulo, SECTRA and *Pontificia Universidad Católica de Chile* (2001) for Santiago, and The Bogotá Project (2000) for Bogotá.

<sup>9</sup> Presentations by contact persons in Santiago, São Paulo, Mexico City, and Bogotá, at the Annual Workshop on Urban and Regional Air Pollution, Mexico City, organized by MIT, January 18-21, 2003.



'Congestion Pricing and Related Options in Latin America' was administered in English and Spanish through the internet over a three month period from January to April, 2005. There were a total of 104 respondents, of which 81 responses were analyzed after excluding 23 incomplete questionnaires. A non-random snowball sampling methodology was followed such that the first emails for the survey were sent to an initial list of transportation experts who acted as key informants in each city. These contacts were asked to forward the email further to other experts. A snowball sample is considered useful for surveying such specialized sub-groups of the population. An explanation of the normally argued objectives of congestion pricing was given at the start of the questionnaire. At the outset, the people surveyed were asked to identify the city they were responding for. Of the responses received, 16 were from Mexico City, 15 from São Paulo, 10 from Bogotá, and 40 from Santiago.

Self-selection of respondents is inherent in a survey of this nature and is a limitation because the results cannot be generalized. This is a common occurrence in surveys that explore policy issues because it is possible that the respondents are all people particularly interested (or disinterested) in the policy and thus tend to answer in a certain way. In our survey, higher levels of tolerance towards congestion pricing were apparent where the policy was more firmly a part of the professional 'knowledge culture'. We therefore state our results only for the group of experts surveyed and do not attempt to generalize the findings. Another limitation is the small sample sizes for each city. Given more time and resources, larger sample sizes would have restricted some of the bias arising from other issues such as self-selection and the non-random nature of a snowball sample.

### **3. History and Experience of Vehicle Restrictions in Mexico City, Bogotá, São Paulo, and Santiago de Chile**

Traffic bans and congestion pricing are both ways to reduce the use of private vehicles and facilitate use of alternative transport modes. However, traffic bans are considered politically easier to implement because of the perception that all sections of the population are treated identically. Congestion pricing, on the other hand, is usually expected to have negative impacts on lower and middle-income car owners making it difficult to gain public approval (Giuliano, 1992; Viegas, 2001). The Latin American cities studied here have all implemented traffic bans for controlling either congestion, or air pollution or both.

In at least two of these cities—São Paulo and Santiago—congestion pricing proposals have been considered in recent times, while in Bogotá the policy was listed as a possible option in the 1997 Master Plan but is still controversial. No other city in the developed world where

congestion pricing has been implemented began at a baseline where vehicle restrictions were already in place. Thus, the Latin American cities are unique in that we might assume public approval for implementing congestion pricing to be more forthcoming, given that people already face some restriction on driving. But the policy is controversial for a variety of reasons, as will be revealed in the survey results. A common perception is that low and middle income car owners might face negative impacts from the policy. However, the additional expenditures of the revenues on transit and the reduction of congestion that currently impedes it would benefit these groups, as well as the majority of travelers who do not own a car. At the outset, it is instructive to study the background, institutional issues and implementation process of the existing traffic bans in each city. The four cases are discussed below in chronological order of their execution of these bans.

### **1) Santiago de Chile**

Car ownership in the Santiago metropolitan area (Greater Santiago) was relatively low at 60 cars per thousand inhabitants in the year 1977. Through the sixties and the seventies, this motorization rate remained low partly due to the heavy import taxes and restrictions on car purchases, and partly due to economic problems in Chile during the seventies. In the late 1970s, however, the import restrictions on cars were eliminated, leading to the availability of cheaper and better cars. After this change, within only two decades, between 1977 and 1997, the motorization rate in Greater Santiago doubled to 120 cars per thousand inhabitants. Over the past decade, the number of private vehicles in Santiago has grown at an annual rate of about 10% (O’Ryan *et al.*).

The *restricción vehicular* (traffic restriction) policy in Santiago was implemented as a response to traffic congestion and air pollution in 1986—the earliest of all cases studied. The policy limited the circulation of 20% of buses, taxis, and cars between 6:30 AM and 8:30 PM on weekdays based on the last digit of the vehicle’s license plate number, with two digits restricted on each weekday (Bull, 2003). Originally planned only for the days of extreme pollution, or ‘emergency’ pollution days, it is now a permanent measure and is applied in the nine months of high pollution risk in the year (March to December). On days of extreme pollution, the restriction applies to more vehicles—40% of the total fleet—for a longer duration. In addition, the schedule for the *restricción vehicular* is changed every few months to prevent the possibility of households purchasing more cars in order to circumvent the restriction. Since 2001, the vehicles with catalytic converters have been exempted from the restriction as a means to stimulate fleet turnover to cleaner vehicles (Zegras and Gakenheimer, 2000). This has made

the policy controversial because the congestion reduction benefits diminish as more people acquire vehicles with catalytic converters to avoid the restriction. The policy is therefore, also considered discriminatory towards the poor who cannot afford the newer cars. Zegras and Gakenheimer (2000) write that the *restricción vehicular* has generally received public support, but faced opposition mainly from the auto industry and vehicle owners.

The sequence of events in considering further transportation demand management measures in Santiago is as follows. In 1995, the Transportation Secretariat (SECTRA) of Santiago prepared a 15-year Development Plan for the Urban Transportation System of the city with goals of maintaining the mode split and limiting the rise in automobile usage. It is worth noting that even over a decade ago, the recommendations of the Development Plan had a number of market instruments included, such as requiring all vehicles except buses to pay a road user charge of US\$4 to enter the city center during peak morning hours. This was proposed to later become a variable charge ranging from 12 cents to US \$4 per kilometer in different parts of the network depending on the time of day and level of congestion. Another measure proposed was the implementation of parking charges that varied by trip purpose and duration of parking. But none of these measures were adopted, with the specific proposal of road user charges being rejected by politicians. This plan of SECTRA's was considered a first step towards many important measures to modify travel behavior with the aim of reducing traffic congestion and greenhouse gas emissions in Santiago. However, none were implemented, and the rapidly growing car ownership in the city made it clear that much "political and educational effort" would be required to bring about these behavioral changes (O'Ryan *et al.*, 2002: p.14).

Later, in 1998, the National Commission for the Environment (CONAMA) launched a plan called the Greater Santiago Air Pollution Prevention and Decontamination Plan. The Plan was prepared in collaboration with multiple government agencies, non-government organizations, businesses, and academics, again with several measures included for managing private travel demand. These included restraints on the use of cars, taxis, and trucks, reduced parking availability, higher parking charges, road user fees, higher registration fees for polluting vehicles, and peak hour prohibitions for truck circulation in certain parts of the city. Other measures included the introduction of new fuel standards, new communications technologies for better traffic management, and improved pedestrian, cycling, and transit facilities. The objective of this plan was to meet required air quality standards by 2011, and a detailed implementation plan was designed with enforcement responsibilities specified. However, only about half the measures—the least controversial ones—have been implemented to date (O'Ryan *et al.*, 2002).

The road user charges were widely debated and again not applied, while the higher parking charges were only applied in a few areas.

In recent years, the authorities in Santiago have considered road pricing specifically for environmental reasons. The *restricción vehicular* described earlier is in operation for most of the year. Still, the growth in car ownership at a rate higher than income growth has created the problem of traffic congestion and hampered the sustainability of any measures taken to improve air quality. At present, a road pricing scheme has been planned for Santiago with a dual purpose—(a) to fund new infrastructure, and (b) to charge drivers the external costs of air pollution and congestion through higher tolls during peak hours. It will be implemented over the entire network of newly concessioned roads in the city<sup>10</sup>. For reasons of public and political acceptability, it was considered easier to introduce pricing for the first time on new roads than on existing roads. At the time this paper was written, six urban toll road concessions had already been granted to private operators with most of the investment and operating costs to be covered by tolls. There would be a similar differential charging structure for all the roads, with three levels based on the time of day and level of congestion. The default charge would be about US 6 cents per kilometer, increasing to 12 cents per km in peak periods, and to 18 cents per km when speeds consistently drop below 50 km per hour (Willumsen, 2005). An important feature of the open road Electronic Toll Collection (ETC) system as it is called, is that concessionaires are required to distribute one million electronic vehicle identification tags free of charge for all cars owned by households in the city. The tags would be linked to individual accounts from which charges would automatically be deducted by gantries located at points in the road network.

Toll collection is already in operation on a north-south facility in the city since December 2004. Willumsen (2005) writes that the system in Santiago is akin to the way people pay for mobile phone charges, and costs relatively less than setting up a system of payment centers as has been done in London. Apparently, users have understood the technology well so far and adoption has been simple. The distribution of free tags has no doubt helped reduce some of the public inertia in adopting the new system. It is still not known whether users would prefer the replacement of the *restricción vehicular* by the road pricing system but the experts remain optimistic, especially in light of the mixed acceptance of the *restricción vehicular*. The toll revenues will be spent by the city towards paying for the new infrastructure while the surplus

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<sup>10</sup> Quoting from an email exchange with Oscar Figueroa (October, 2004), “*The idea of an area based system has been systematically rejected by authorities and by experts. The result is that [the] project has never been approved and probably never will be.*” Thus, road pricing appears to be the preferred method for charging approximate marginal social costs on certain roads, varying according to the level of congestion.

revenue from increased tolls at times of congestion would be spent on a variety of other projects. Experts in the city feel that with the ETC system and technology in place in Santiago by 2006, the time is not far when the same technology will be used for location-specific congestion charging at key road sections in the city. The use of revenues from the ETC system for public projects is also expected to influence the acceptability of future congestion charging proposals.

## **2) Mexico City**

The vehicle restrictions in Mexico City began in 1987 as a voluntary initiative led by an environmental group called *Mejora tu Ciudad* (Improve your City). As part of the *Hoy No Circula* program ('No Driving Day') as it was called, the group persuaded drivers in the Mexico City Metropolitan Area to avoid the use of their cars for one day in the week. Initial responses to the program were positive but it was not promoted effectively. In 1989, the metropolitan area was faced with severely high levels of atmospheric ozone—a common occurrence during the winter months, and facilitated by incomplete combustion of automobile fuel. The government of the Federal District of Mexico City then implemented the *Hoy No Circula* as part of the emergency measures to deal with high ozone concentrations. The program banned the circulation of 20% of all private vehicles on each weekday between 5 AM and 10 PM as a strategy to reduce congestion, pollution, and fuel consumption by reducing the total number of vehicle-kilometers traveled (Molina and Molina, 2002). The ban was based on the last digit of the vehicle's license plate number as in the other cities. Ex-post studies done for that year showed favorable impacts such as a decrease in fuel consumption, and increased subway ridership and road speeds. Thus, the program was made permanent in 1990 as part of Mexico City's first regional air quality management program (*Programa Integral Contra la Contaminación Atmosférica*—PICCA). The program formally prohibited car use for one day of the week with non-compliance leading to a fine. Later, to make it more effective for air quality improvement, it was extended to all vehicles in the metropolitan area, including taxis, buses, minibuses, and trucks.

While the *Hoy No Circula* program began with public support in the initial years, those who could afford to buy a second car increasingly began to circumvent the regulation by using their second car on the days when the first one was restricted. According to a 1995 study by the Mexican government, the program caused 22% of drivers to purchase a second vehicle, leading to the unintended consequence of an increase in total vehicle-kilometers traveled in the city (Eskeland and Feyzioglu, 1995). The impact on air quality improvement was limited too

because the second car that many households purchased in response to the regulation was usually an old, inexpensive, and polluting vehicle.

According to critics, the *Hoy No Circula* program is inefficient, leading to wastage of a part of the car's capital cost and a loss in productivity (Villegas-Lopez, 2000). The program has not been very effective as a measure to reduce air pollution because of the addition of more polluting vehicles to the fleet, though it helps ease congestion given the rising use of private automobiles in the city. This is evident from the severe congestion that occurs in several areas of the city on weekends and holidays when the vehicle circulation ban is not in operation. Another criticism is that it has increased the inequality in private mobility. Eskeland and Feyzioglu's (1997) study showed how low and middle-income households formed the largest group of car sellers as a result of the policy and it was mainly the high-income households that constituted the group of car buyers. Their evidence also shows that Mexico City turned from a net exporter of used vehicles to the rest of the country between 1983 and 1989 before implementation of the *Hoy No Circula* to a net importer of used vehicles between 1990 and 1993, under the regulation.

In 1995, due to continuing concerns about air pollution, the *Hoy No Circula* program was further modified 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. Since then, as in Santiago, the program has helped mainly in accelerating the modernization of the vehicle fleet in the metropolitan area by allowing only clean vehicles to run on the city's roads on most days of the year, including all emergency-pollution days (Molina and Molina, 2002). This has led to fewer vehicles being restricted through the *Hoy No Circula*—only 7.6% of vehicles in 2003 as opposed to 20% of vehicles that were restricted when the policy was adopted in 1989 (SMA, 2004).

Another traffic restriction proposed by the Secretariat of the Environment of the Federal District of Mexico in 2001 was to ban all vehicles from entering the old city center, the *Centro Histórico*. Consultations were held with various stakeholders, after presenting data on potential emissions reductions possible from banning the entry of vehicles into the city center. The proposal however, did not move ahead due to opposition by many groups, including automobile manufacturers and distributors, freight companies, and downtown businesses. Congestion today is so acute in Mexico City that the *Hoy No Circula* is considered better than nothing, and the authorities are planning to enforce it much more strictly. In spite of the acknowledgement that congestion is a serious problem in the city, congestion pricing is certainly nowhere on the

agenda. There was also no formal discussion or documentation in this regard apart from earlier research initiated by the authors in 2003 (Mahendra, 2004).

One recent transportation development that occurred in May, 2005 is the opening of a Bus Rapid Transit (BRT) system on *Avenida de los Insurgentes*—a prime corridor with high traffic levels in Mexico City. Since the BRT system has replaced the *colectivos* (minibuses) and standard buses that formerly operated on the corridor, experts surmise that it will mainly be used by low and middle income people who relied on the buses earlier. This is a demonstration project that has resulted in a reduction of travel times on the corridor by alleviating the congestion caused by minibuses. Its success will determine whether it is replicated in other parts of the city or not.

### **3) São Paulo**

Among the municipalities that make up the São Paulo metropolitan region, the capital of the state, the city of São Paulo, has the highest concentration of automobile traffic as well as the highest political power. There is constant tension between the state or regional agency and the local city authorities with respect to policy-making in São Paulo. The experience with vehicle restrictions in this city has been relatively positive. This may be attributed to a more environmentally conscious decision-making culture in the state of São Paulo (Hochstetler and Keck, 2004).

Vehicular pollution is currently considered the major source of air pollution in the metropolitan region. In the past, the National Environment Council (CONAMA), São Paulo's Technical Agency for Environmental Sanitation (*Companhia de Tecnologia de Saneamento Ambiental*—CETESB), and the Environmental Secretariat of the State of São Paulo have used both regulations and incentives to control emissions from private automobiles. These policies have focused on the human health impacts of air pollution for over thirty years, with climate change and global warming emerging on the agenda only in the 1990s (Hochstetler and Keck, 2004). It has proven to be a challenge to carry out inspections of the large automobile fleet in the São Paulo municipality to check for compliance with emissions standards. This is primarily due to the conflict between the state and municipal environmental agencies about who ought to be liable for conducting the emissions tests. While these conflicts have been on, São Paulo's automobile fleet grew from 2 million cars in 1985 to 3.4 million in 2002, outpacing the growth in metropolitan population from 13 million to 17 million in the same period.<sup>11</sup>

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<sup>11</sup> These numbers are obtained from official origin-destination survey data for the metropolitan area published in 2003 (DM, 2003). According to a reviewer, the O-D survey data only consider vehicles belonging to households and hence,

Under these conditions, the State Secretary for the Environment, Fábio Feldmann, took office in 1995. Feldmann is credited for being an extremely active official who ensured that environmental issues received due importance in his term. He implemented the *rodízio* (rotation) policy that restricted the use of 20% of the car fleet in most of the São Paulo metropolitan area between 7 AM and 8 PM on each weekday, based on the last digit of the vehicle's license plate number—a scheme similar to those already adopted in Mexico City and Santiago.

But what has been unique in São Paulo is the process of using the *rodízio* program to persuade people to change their travel behavior and to educate them about the environmental repercussions of the growth of automobiles. A survey of 1,000 São Paulo residents conducted in the early nineties revealed that air pollution was considered the prime environmental problem at the neighborhood level by most respondents, with 89% of respondents agreeing that some government action was necessary to solve the problem (Jacobi *et al.*, 1999). To respond to these public views, the first *rodízio* was started in 1995 as a voluntary scheme. While the program was criticized in the media<sup>12</sup>, a positive result was that 38% of drivers complied with it even though it was voluntary (Jacobi *et al.*, 1999). With the support of numerous environmental organizations, the local environmental agency CETESB provided extensive public information<sup>13</sup> on the health risks of air pollution and involved the different levels of government from the environment, transport, and health sectors in discussions on sustainable transport policy (Hochstetler and Keck, 2004). The success of the voluntary trial scheme encouraged state representatives to legalize it in 1996.

The *rodízio* program was formally authorized by the state authority for two years to start with. It was primarily intended to control the high levels of air pollution in the metropolitan region, including the city of São Paulo and nine other municipalities, in the three winter months from June to August. Its implementation mainly involved environmentalists, not transport planners. In fact ironically, from the very beginning, the *rodízio* was strongly opposed by local transport and traffic planners in the city of São Paulo. This was not only because they had no involvement in its implementation but mainly because the powerful local transportation agency

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result in lower estimates of the number of vehicles. We found much higher figures for the number of vehicles in São Paulo, for example, in Hochstetler and Kech (2004).

<sup>12</sup> Jacobi *et al.* (1999) suggest that this is possibly due to an over-representation of car owner interests in the press while the users of collective transport—the major winners in the exercise—remain less vocal.

<sup>13</sup> The State Environmental Secretariat and CETESB educated people about the *rodízio*, its operations, rules, and beneficial environmental impacts. Brochures and pamphlets were handed out in public places, celebrities were asked to help spread the message, journalists were openly provided information, and over three million phone calls were made to citizens in 1996 as steps to provide extensive environmental education. Source: *Secretaria de Estado do Meio Ambiente* (SMA), 'A Educação pelo Rodízio', (SMA, 1997), quoted in Hochstetler and Kech, p. 28. Also see Jacobi *et al.* (1999, p. 86), for measures taken to educate the public about environmental problems in São Paulo.



they were affiliated with, *Cia de Engenharia de Trafego* or CET, worked for decades to support the use of the automobile. Their agenda never included public modes such as buses or any other environmental topics (Vasconcellos, 2005).

Resident surveys, however, showed that the *rodízio* scheme was considered useful, with especially strong support from those who did not own cars. According to a survey conducted in 1996 by the São Paulo metro, 69% of people considered the *rodízio* 'good' or 'excellent'<sup>14</sup>. The policy was considered successful in its objective of improving air quality, but the chief reason most respondents supported it was the improvement in traffic flow. Before the *rodízio* scheme was implemented, 62% of all regular drivers thought that it would not help reduce air pollution, a number that reduced to 27% after the scheme was implemented. Focus group interviews revealed similar results and through the information campaigns, the idea of 'environmental citizenship', as Feldmann called it, caught on where the citizens cooperated with public authorities in a partnership to improve the environment. 93% of cars adhered to the *rodízio* program, leading to a 19% reduction in carbon monoxide emissions with no levels of alert for carbon monoxide for the first time in ten years (Hochstetler and Keck, 2004).

Still, an indication that there were powerful dissidents of the policy was the fact that Fábio Feldmann was not re-elected for a following term after being the Environment Secretary who implemented the *rodízio*. He received just over half the votes he received in the previous election. Hochstetler and Keck (2004) say in their account of the policy that while there are no reliable studies on this, most people assumed that Feldmann lost much of his largely middle class car-driving constituency due to the *rodízio* program. The new administration following him therefore put an end to the *rodízio* soon after coming to power.

In 1997, however, the *rodízio* was adopted again but this time by the São Paulo municipal authority, and only in a 152 square-kilometer area within the 'enlarged downtown' (*centro expandido*) of the city. In spite of its prior opposition to the vehicle ban for environmental reasons, the local agency comprising the transport and traffic planners, the CET, soon realized that the program had to be adopted for a different reason—congestion. It proposed a 'city *rodízio*' to reduce congestion, although 'reducing pollution' was also mentioned in the proposal. As proposed, the *rodízio* program currently in operation for 11 months of the year became permanent in 1999, limiting circulation in peak hours, between 7AM-10AM and 5PM-8PM on weekdays in the central areas of the city. The program was accepted by most people, especially because the restriction was milder than the previous all-day restriction (7 AM

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<sup>14</sup> Eduardo A. Vasconcellos, personal communication through email, August, 2005, quoted from *Avaliação da Operação Rodízio/97 Pela População Metropolitana*, São Paulo, 1997.

to 8 PM), it covered a smaller area, and because congestion did reduce perceptibly. Even two years after its implementation, the *rodízio* restriction had kept peak hour traffic down by 14% (Viegas, 2001). It presented evidence that substantial reduction in air pollution was possible by only slightly reducing the number of vehicles in circulation in the city. The increased gains are largely attributed to a reduction in congestion and improvement in efficiency of public and private transport (Jacobi *et al.*, 1999).

In recent years though, the vehicle fleet in São Paulo has been increasing rapidly in spite of the *rodízio*. Evidence indicates that 25% of restricted drivers have bought more cars with varying last digits on the license plates. The fixed schedule of the *rodízio* makes it simpler for people to beat the system as also seen in Mexico City. Thus, there has been a growing interest in congestion pricing due to high levels of congestion and vehicle kilometers traveled in the city. The city has set up a task force to evaluate various proposals for congestion pricing. One proposal that has come up is that of a three-zone area-based congestion charge with differential charging within three concentric rings around the city center (Hook and Ferreira, 2005). This was supported by Mayor Marta Suplicy whose term ended in 2004, leaving the political fate of the proposal uncertain. Experts however, recognize the need for an alternative and are continuing to analyze the feasibility of the policy in São Paulo. Most recently, a public opinion survey on road pricing was conducted in October 2006 in major Brazilian cities. Of the respondents from São Paulo, only 37% (including drivers and pedestrians) were familiar with the concept of road pricing (*Folha de São Paulo*, November 14, 2006), indicating a clear need for public information before any such proposals are put forth publicly.

#### **4) Bogotá**

Vehicular restrictions were first implemented in Bogotá in 1998 as part of a program called *Pico y Placa*. This measure restricted 40% of private vehicles from operating in the city each day between 7–9 AM and between 5:30–7:30 PM. Vehicles having any of four digits as the last digit of their number plate are restricted each day (Breithaupt and Fjellstrom, 2002). Thus, each vehicle is restricted from circulation during peak hours on two days of the week. Bogotá is unique in that the program was implemented as a response to traffic congestion and not air pollution as was the case in the other three cities.

The experts consulted for this research provide varying accounts of what motivated the program. One view is that it was due to the factors that caused a rapid growth in motorization, exacerbating traffic congestion in Bogotá in the early nineties. The growth of personal income and a reduction in tariffs for automobile imports made cars more affordable in that period,

leading to a rising rate of car ownership. At the same time, the local government lacked resources to invest in increasing road capacity. Thus, the idea of vehicle restrictions was put forth by academics and transportation consultants as a short-term method to alleviate congestion. Around the same time, the Bogotá Transport Master Plan for 1997 (JICA *et al.*, 1996: 455) was being prepared that included congestion pricing as one of the travel demand management measures recommended for the city (Hidalgo, 2005).

Other accounts state that the *Pico y Placa* scheme was implemented at the time the exemplary Bus Rapid Transit (BRT) system of Bogotá, the TransMilenio, was being planned. Planners feared that the construction works on key corridors of the city that were required for the new transit system would lead to a collapse of urban mobility since there were limited alternative routes through which traffic could be detoured. Another stated rationale for the program was thus, to curb congestion while the TransMilenio was being constructed in order to prevent chaos in the city's traffic system. The environmental argument for preventing air pollution was but marginal in any discussions, with congestion reduction being the driving force behind implementing the *Pico y Placa* restrictions (Ardila-Gómez, 2005).

The mayor of Bogotá at that time, Antanas Mockus (1996-1997), floated the idea of all-day restrictions and held a public consultation process for it along with polls. Neither the media nor the public favored the idea at the time. The failures of Mexico City's then operating *Hoy no Circula* and Santiago's *restricción vehicular*—both vehicle restrictions imposed to control air pollution—were publicized by the media and transportation experts. Experiences from these cities showed that families bought a second vehicle that was usually cheaper, older, and more polluting to use on the day their routine vehicle was restricted.

Given these lessons from the other cities, a year later the new administration of Mayor Enrique Peñalosa, changed the proposal for the *Pico y Placa* scheme from all day-restrictions to peak-hour-only restrictions. The idea was again proposed publicly in 1998, leading to an informal debate in the media. Although certain groups of people such as those associated with the media, the chambers of commerce, and the retailers' trade unions opposed the idea, there was uncertainty regarding the general public reactions to the new proposal. Still, in June 1998, Mayor Peñalosa who strongly supported the proposal signed a decree to make the *Pico y Placa* program permanent (Hidalgo, 2005).

Over the years, the program has helped significantly in reducing peak hour congestion in Bogotá. While congestion has reportedly worsened in the hours before and after the restriction period, peak hour travel times have reduced by 40-50% and car users have managed to change their schedules, car pool, or use taxis. In 2001, with the opening of the TransMilenio Bus Rapid

Transit system in the city, some car users also shifted to public transport. The problem of buying another car that occurred in the other cities did not occur in Bogotá because used cars have been significantly expensive in Colombia since an economic downturn in 1999, and most families did not have the resources to buy a second car.

The *Pico y Placa* program in Bogotá is considered successful even after close to a decade of implementation and three successive mayoral terms. The reasons are that the benefits are evident to most people and the majority of people are not against the scheme, given that only 15% of total trips are made by private vehicles in the city (*El Tiempo*, 2004). In 2004, under the new Mayor, Luis Garzon, the schedule for the restrictions was extended from two to three hours in the morning and evening peak periods. Some experts believe that this current restriction—from 6 AM to 9 AM in the morning and 4 PM to 7 PM in the evening—is less amenable to accommodating work schedules and may have therefore stimulated sales of second-hand automobiles. However, the schedule of the *Pico y Placa* scheme is changed once a year to avoid precisely this unintended impact.

What can perhaps be considered a daring step by the city administration is a suggestion to make the peak-hour restriction apply to all vehicles in the city on all weekdays starting from 2015. The authorities say that this would allow time to develop the public transport system further, along with the development of non-motorized transport facilities and the transformation of land uses. A public referendum was held for this measure in the year 2000 and surprisingly, 51.3% of valid votes cast by over a million people were in favor of the restriction, 34.3% were against it, and the rest were blank votes (*El Tiempo*, Nov. 3, 2000).

While the *Pico y Placa* program is considered successful in many respects, some experts oppose it because they believe that it fosters institutional complacency. In spite of the low level of car ownership and use in Bogotá, congestion prevails due to limited road capacity and disruptions due to TransMilenio's second phase of construction on key corridors. The gaps in the road network and inefficient management by the urban transportation agency are believed to exacerbate the traffic problems. Much needed institutional strengthening is easily postponed by adding another hour to the *Pico y Placa* schedule in the hope that it will diminish congestion to some extent (Ardila-Goméz, 2005).

Nevertheless, transportation policies in Bogotá generally are not in favor of car use. Complementary to the *Pico y Placa* program, and along with the implementation of the TransMilenio, parking fees in the city have recently been increased by 100%, and gasoline taxes have been increased to 20% of the sale price. In addition, other promotional and educational measures have been followed to reduce car use such as an annual event called the

'Day Without a Car' when all residents leave their cars at home, the closing of major roads to car traffic from 7 AM to 2 PM on Sundays and holidays, encouraging the use of bicycles along with construction of a network of bike paths throughout the city, and the expansion of the TransMilenio Bus Rapid Transit system. All these measures have supported the objective of the *Pico y Placa*, possibly facilitating its widespread acceptance.

Transportation experts in Bogotá acknowledge that despite these measures, certain locations such as the central areas of the city and the affluent northern areas continue to remain congested with car traffic. Also contributing to the traffic problems in Bogotá is the fact that the affluent area is unusually confined on the side of a mountain. Tolls on national and regional roads going out of the city do exist, but vehicles entering the city are not charged. A few years ago, a proposal for tolls to access the city from neighboring communities was rejected by the city council because the neighboring municipalities lobbied strongly against it. But in present times, the high pollution levels, non-compliance with pollution standards, and the adverse effects on public health have been publicized as important environmental problem that deserve attention. This might play a role in promoting some interest in alternative demand management policies, given that the increasing number of vehicles contributes the most to air pollution in the city.

#### **4. Case Summary**

Some key points to summarize this section follow. The reasons for congestion in Bogotá are different from the other cities given the low car ownership level. The inefficient management of the road network is considered responsible for much of the problem; not growing car ownership. The *Pico y Placa* scheme in Bogotá helps ease congestion, and is strongly reinforced by other complementary transport policies and promotional measures. Public education also seems to play an important role in the success of the *Pico y Placa*. It appears that the city may lack the capacity and agreement among experts to implement congestion pricing and as yet, there is no reason to do so, given the other initiatives to discourage car use that are in effect. São Paulo's *rodízio* program as we know it today was largely implemented to manage congestion but a previous version was used to target air pollution. Due to extensive public information about the rationale and benefits of the program, and widespread public education about the problems of congestion and air pollution, the program has largely been acceptable. Congestion pricing is now under consideration in the city because the vehicle fleet has shown no signs of stabilizing in spite of the *rodízio*.

In Santiago, pricing-based instruments to manage congestion and air pollution have been repeatedly included in the planning agenda since the mid-nineties but have never been implemented due to political reasons. The *restricción vehicular* in operation for most of the year has not received much public support and has not helped attenuate the growth in car ownership and use. This is possibly the reason that the new Electronic Toll Road system combines infrastructure tolls with variable pricing based on levels of congestion, as an initial attempt at road pricing in the city. In Mexico City, while the higher income households are able to get around the *Hoy No Circula* policy by purchasing additional cars, the lower income car using households are compelled to abide by it. The policy has not helped reduce air pollution perceptibly but one reason for public support is the prospect of extreme congestion in the absence of the program. The following section links these case histories to the findings from a survey of 81 transportation experts from the four cities.

## 5. Findings

Of the 81 respondents surveyed from the four cities, 40% were from universities or academia, 32% were transportation consultants, and 15% were from state and local government agencies. 87% of all respondents were familiar with the concept of “congestion pricing”<sup>15</sup>, 11% were not completely familiar, and 2% were not familiar at all. While a brief explanation of the objectives of congestion pricing was provided at the start of the questionnaire, this question revealed that subsequent responses were mostly well-informed. This ensures that the survey responses can be considered reliable. Table 2 summarizes key findings from the survey. A discussion of the results follows.

### TABLE 2 ABOUT HERE

#### **1) Perceptions of Congestion as a Problem and Options to Manage it**

Any form of road pricing is most easily implemented where there is a perception of a serious problem (Ison and Rye, 2003). Santiago de Chile was a case that appeared significantly different from the others. Only 20% of the Chilean respondents thought that congestion was a

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<sup>15</sup> A brief description of the policy and its objectives was provided at the start of the questionnaire before respondents proceeded to answer the questions. The question regarding familiarity with congestion pricing helped ensure that a significant percentage of all respondents, 87%, were well-informed about the theme of the questionnaire. However, due to sampling limitations, the responses to this question are not expected to reflect the actual level of information about congestion pricing among experts in the four cities. The numbers are also not expected to reflect the level of discourse about congestion pricing in each city as the sample sizes are not representative.

critical problem, with the majority considering it a reasonable problem that was not yet very serious. The driving restrictions were considered responsible for alleviating congestion by 48% of respondents. It is possible that the pace of road improvements and construction in Santiago has been quick enough to avoid extremely congested conditions. Several concessions for new toll roads in the city are soon to be open to the public, with a key north-south corridor already operating since December 2004. While the city has been considering congestion pricing proposals for over a decade now, there has never been enough political support to implement them. These survey responses possibly provide the reason—it is plausible that the problem of congestion is not considered sufficiently serious by many experts and decision-makers themselves.

When asked about the effect of the traffic bans on relieving congestion, the response was relatively moderate in Mexico City and Santiago. Only 44% of experts in Mexico City and 48% in Santiago considered the impact of the restrictions positive. In contrast, 93% of the respondents from São Paulo and 80% from Bogotá considered the impacts of the traffic bans positive. One reason for this difference of opinion may be the fact that Santiago and Mexico City have day-long restrictions, while Bogotá and São Paulo have the bans in effect only during peak hours and as such are less disruptive. This is an interesting observation because it suggests that in planning for congestion pricing too, acceptance for time-differentiated congestion pricing might be higher than for a flat daily “access” charge as is the case in London.

In one of the important survey questions, we presented the respondents with several policy options for managing traffic congestion (see Figure 1). We asked them to rate these in order of their suitability in their city. Overall, the option to expand and improve public transport with systems integration ranked highest by all respondents for possible solutions to managing traffic congestion. The next highest ranking response in Mexico City, Bogotá, and São Paulo was to introduce physical restraints such as bus-only lanes and pedestrian zones. It is possible that the high ranking of this option may be due to respondents interpreting this as one form of improving public transport, the top ranked option in all cities.

However, in only the case of Santiago, the next highest ranking response for managing traffic congestion was the introduction of some form of congestion pricing. The low ranking responses in all cities were the expansion of road capacity, increase in fuel taxes, and the option of raising car ownership taxes. The responses to this question do not differ much from the rhetoric that one hears in the field—about the benefits of public transport improvements to prevent further growth in traffic congestion. In addition, these responses by professionals, academics, and government officials indicate a divergence from the policy agenda being

followed in the four cities. The main evidence of this is the unanimously low ranking of the option to increase road capacity to manage congestion. This is not really reflected in cities like Mexico City where the controversial *Segundo Piso* project has recently been built to add a second level on an existing urban highway, or in Santiago where several new highways have recently been concessioned.

## **FIGURE 1 ABOUT HERE**

An interesting finding was that even though the Chileans were the only group that felt the traffic congestion problem in Santiago was not yet critical, they were most in favor of implementing congestion pricing as a possible solution to manage congestion. This could partly be explained by the fact that the Chileans are naturally keen on experimenting with transportation innovations, given the sophisticated level of transportation expertise that exists in Santiago. Santiago was also the first city in Latin America to adopt the vehicle restrictions. With congestion pricing under debate in Santiago for over ten years, there is undoubtedly a lot more awareness and discussion and a much more evolved knowledge culture with respect to the policy in that city.

### **2) Challenges to Implementing Congestion Pricing**

The lack of political will<sup>16</sup> for adopting congestion pricing was considered the biggest challenge (ranked 1) by the largest percentage of total respondents—54%, followed by the absence of information at the decision-making levels—a response given by 34% of those surveyed. While the lack of political will ranked highest as a challenge in case of São Paulo, Bogotá, and Santiago, the respondents from Mexico City considered the lack of public knowledge or information at the decision-making level the biggest challenge towards implementation. Among other challenges included in the survey questionnaire (see Annex, question 10) were lack of alternatives to driving, enforcement problems, lack of transparency in managing revenues, and high operating costs of a pricing scheme. The lack of funds to execute a pricing scheme may be considered an important limitation in the context of developing countries, but interestingly, it was ranked highly (rank 1 or 2) only by 11% of respondents and overall had the lowest weighted average score.

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<sup>16</sup> Some respondents remarked that the lack of political will was related to the lack of alternatives to driving. This is because people who opposed the policy did so because of limited existing alternatives to using their cars, and this opposition from large sections of the populace is what weakens political will.



We followed this question by asking all respondents to specify other important challenges to implementing congestion pricing in their cities. The answers provide insights into the specific concerns for each city and bring to light several issues relevant for other developing cities too. In Mexico City, a key challenge mentioned was that many affluent car owners would not be sensitive to the higher cost of a congestion charge. Mexico City also has a sizeable car-owning middle class (unlike Bogotá) that would potentially be against the policy.

In addition, enforcement of such a charge was expected to be a problem for two reasons—first, the unreliability of current vehicle registration databases, and second, the fact that different local jurisdictions have their own separate databases. This would make it difficult to match license plate numbers, as is being done in London, especially for vehicles coming into the metropolitan area from the surrounding states. Other comments made by Mexican respondents were that transportation studies in the city are not generally credible, better public transport was needed in order to make congestion pricing work, and finally, the mindset of commuters in the city who considered owning a car to be a status symbol was a significant challenge.

The limited access to public transport was considered a major problem in São Paulo. One respondent suggested the need to implement a pilot program in ‘a less complex and smaller city’ because of the aggressive political environment in São Paulo. While congestion pricing is currently being discussed in the city, decision-makers and politicians are treading very cautiously in anticipation of a strong public reaction. According to one respondent, there was likely to be *‘a profound public reaction because Brazilians are subject[ed] to constant tax increases of all types. The media would be against it as well’*. According to one of the key informants, *‘the power of the middle classes to influence policy decisions’* was the most difficult challenge to overcome in São Paulo.

Similar to the views for Mexico City, in Bogotá too, operational issues with implementation were considered a problem. These include the lack of a reliable vehicle registration database that would make the design and enforcement of a London-type congestion pricing scheme difficult. Another issue was that the transportation planning community in Bogotá did not agree on the merits of congestion pricing. Respondents mentioned that since decision-making and public discourse through the media were in the hands of car users in Bogotá, it was unlikely that any action that was against their interests would be taken in the city. This point is likely to be true for all the cities under study.

In Santiago, respondents believed that the implementation of the new integrated public transport system (Transantiago) would provide a better alternative to driving, making congestion

pricing more feasible; however, there has always been strong opposition by the car lobby. While six major private urban toll roads with Electronic Toll Collection were scheduled to open in 2006, the tolls would mainly be charged to recover the investment. It is expected that sophisticated time-differentiated congestion pricing would in time become a feasible option using the established toll collection infrastructure. Other challenges cited by respondents from Santiago were the lack of public knowledge about the policy, the high income inequality in the city, and the fact that many lower income people consider the use of a car a symbol of a better life and may oppose a congestion charge on the grounds that it is not fair, or '*for emotional reasons*', as one respondent put it.

### **3) Expected Impacts on Low-Income Car owners**

Congestion pricing is bound to have negative impacts on certain groups of people, such as low and moderate-income car drivers, and those who live farther away from the centers of employment with marginal access to public transport. In considering the best ways to compensate these groups of people (see Annex, question 9), a sizeable 78% of all respondents ranked highest the option of using the pricing revenues for public transport improvements. The reason given was that low- and middle-income car drivers would be most likely to shift to using better quality public transport if their cost of traveling by car increased. This response could also be a result of lessons drawn from the London Congestion Charging scheme that is widely considered successful. In London, the revenues from a congestion charge imposed for driving into Central London have been mandated by law to be used for public transport improvements for a period of ten years. A Mexican respondent gave the following explanation,

*'The only really feasible compensation option I see is public transport improvements. The others would be administratively too difficult or costly.'*

For Bogotá, the option of using the revenues for maintaining and expanding roads also ranked highest along with public transport improvements, possibly because of two reasons. First, the road network is generally believed to be lacking in Bogotá and many respondents mentioned the need for improvements. Second, the TransMilenio BRT is heavily used by lower income people, runs on roads, and is the primary means of public transport in the city so that the use of pricing revenues to invest in expanding the BRT network was considered important. The choices we provided for this question also included the option of 'no compensation is necessary' that was interestingly ranked highest by a substantial 12% of all respondents. Other remarks however revealed that some respondents answered this way because they considered

the notion of 'low income car owners' alien to their society. In the words of one respondent from Bogotá,

*'In our society, there are two groups—car owners and no car owners. [The] first is [composed of] rich people, [the] second is [composed of] poor people, so the idea of "low-income car owners" is a concept with no sense in our society'.*

A respondent from Santiago also wrote,

*'They should not be compensated, [as] there is no such thing as "low-income car owners".'*

Another question asked respondents who they thought would be most resistant to a congestion charge if implemented. An important finding related to the above was that even though the choice 'low income car owners' was provided, most respondents—61% overall—believed that 'all car owners' and not simply low-income ones would be most resistant to the policy, and this was the highest ranking option overall. This is the chief insight into why there is such low political will to implement the policy rather than the equity issues often cited. When asked if their response about who would resist congestion pricing would change if the policy replaced the driving restrictions currently in force in all cities, 72% of all those surveyed said that it would not. This is again a crucial finding that emphasizes the above point. We might suppose that the idea of providing a choice would be attractive, such that those who could afford it, could actually pay for using their cars and use them, rather than not being able to drive at all on certain days of the week. But it appears that the extra cost anticipated from a congestion charge would deter all car owners from supporting the policy, not just low income drivers. One of the respondents from Bogotá made the following comment, summarizing this issue.

*'I already mentioned that the resistance to congestion pricing will result from the fact that those making policy (or commenting [on] policy in the media, trade and professional organizations) are those using cars. The equity factor does not seem [to] play a major role in the discussion as long as there are not that many medium and low income car users. It seems more "fair" to have car restrictions than pricing, but pricing is a very interesting complement to car restrictions if funds are used to expand non motorized facilities and public transport'.*

#### **4) Expert opinion about local implementation of congestion pricing**

Finally, to conclude the survey, all respondents were asked whether they thought congestion pricing was an appropriate way to manage congestion in their cities. About 72% of all respondents answered positively. In Santiago, as mentioned earlier, the discussions on congestion pricing have been continuing for over a decade, and this more evolved knowledge

culture is possibly the reason for the more positive responses with regard to the policy. In addition, some experts consider the new toll roads to be a first step towards congestion pricing. In São Paulo, even though the policy has been discussed recently in government circles, with proposals for congestion charging zones around the central business district, it appears that it is still controversial. Bogotá's Master Plan prepared in 1997 also described the option of a pricing-based demand management scheme; however, the discussion was never brought into the public and political realm. In Mexico City too, there has been no government-level discussion about the policy. The fact that a majority of respondents answered this question positively for Bogotá and Mexico City is possibly due to the general endorsement of the policy by many transportation professionals, the sub-group of people who answered this survey. The following section presents some conclusions of this work.

## **6. Conclusions and Discussion**

This research reveals that the manner in which the four cities manage their vehicle restrictions and their success or failure at doing so provides useful lessons for adopting a more sophisticated travel demand management policy like congestion pricing. From a study of the history of traffic restrictions in each city and an exploratory survey of transportation experts, three aspects stand out as important preconditions for pricing policies to be implemented:

- (1) Widespread public information campaigns regarding the environmental and health risks of traffic congestion and resulting air pollution, as done in São Paulo and to some extent in Bogotá.
- (2) The implementation of complementary measures such as enhancement of public transport and increase in parking charges as seen in Santiago and Bogotá. This requirement for congestion pricing has been substantiated well in literature (Goodwin, 1990; Giuliano, 1992; Small, 1992; Levine and Garb, 2002).
- (3) Increased discussion and awareness among experts and politicians about congestion pricing measures with systematic modeling and analysis of alternative policies.

Another factor that we consider important but that could not be verified with certainty in this research is the public perception of the effectiveness of the traffic bans. We would expect that if people perceive the traffic bans to be effective in achieving their objectives, there may be higher acceptability for congestion pricing proposals that include public transport improvements. The credibility of government authorities also plays a role here because the management of revenues obtained from pricing is an important consideration. Since we only surveyed transportation experts and not the general public, we do not have this information. The lack of

political will is also an important factor for implementation though we expect it to be directly related to the third factor—awareness among decision-makers about the policy and its potential impacts.

The first two preconditions are the same ones that contributed to the success of the traffic bans in at least two of the four cities. Still the responses of the authorities to the impacts of the traffic bans differ in each city. The bans are considered successful in both Bogotá and São Paulo. The use of traffic bans—along with public transport improvements, application of other economic instruments such as parking charges and increase in fuel taxes, and measures to promote non-motorized transport and reduce car use—is considered adequate to manage travel demand in Bogotá. There is no consideration of congestion pricing yet by city authorities and the growth in car ownership is not considered a major problem. However, in São Paulo, growing car ownership has undermined the effects of the traffic ban in spite of recent expansion of the city's metro system and better integration of public transport modes. Where the bans have had limited or no success in achieving their objectives, again the responses have been different. In Santiago, the tolls on new roads are considered an attempt to test the waters, as it were, of public acceptance for congestion pricing, before moving on to larger scale implementation of the policy in other parts of the city. In the initial phase, the tolls will exist alongside the *restricción vehicular*. The authorities in Mexico City, on the other hand, are planning modifications to the existing *Hoy No Circula* scheme to ensure stricter enforcement with fewer exemptions, to enable the program to meet air quality targets. Economic travel demand management policies in Mexico City have been limited to the implementation of road tolls and parking charges in parts of the metropolitan area.

Returning to the premise of the paper, we set out to study the conditions under which the existing traffic bans in each city were implemented, to analyze the extent to which these bans had met their objectives, the factors contributing to their success or failure, the lessons that can be drawn for implementing a market-based policy like congestion pricing and the views of the experts in this regard. The three conditions listed above are discussed in the context of each case as follows. São Paulo's reliance on extensive public education and marketing during its *rodízio* program is considered largely responsible for its success and makes the survey respondents relatively more optimistic about congestion pricing. Currently in São Paulo, the area where the *rodízio* has been functioning for many years is the same one being proposed as a congestion charging zone. In Bogotá, the authorities have focused on enhancing public and non-motorized transport along with activities to discourage car use and promote sustainable transport. The *Pico y Placa* restriction has been supported by other measures such as raising

parking charges and fuel taxes. Still, the Colombian experts remain skeptical of congestion pricing as a viable option for their city at the present time.

Santiago de Chile has a story different from the other cities. Not only is the problem of congestion considered milder than it is in the other cities, but the Chileans are already moving towards a sophisticated road pricing system on new toll roads in the near future that will further improve travel speeds in the metropolitan area. Thus, it is not the perception of congestion that is driving the decision to price roads. The road pricing proposals are primarily motivated by a need to control air pollution in Santiago. The traffic ban in operation for this purpose appears controversial. While pricing policies proposed in the past never moved forward politically, many of those surveyed believed that the toll roads would be a first step in the direction of congestion charging.

In Mexico City, the traffic ban has resulted in increased car ownership by the high-income households. Even though the restriction keeps 20% of cars off the roads each weekday, it has not helped limit the rapid growth in car ownership. It is only considered useful because in its absence, congestion would be intolerable in the city. There is no discussion at the political level about congestion pricing and the lack of information about the policy was a major concern highlighted by experts from Mexico City. The overlapping and conflicting levels of government in some cities like Mexico City and São Paulo, the lack of valid car registration databases, limited enforcement, and conflicting priorities for using the revenues were found to be common practical challenges in all cities.

We would like to conclude by emphasizing that the history of vehicle restriction policies offers pertinent insights for the prospects of congestion pricing in the four cities. In addition, it allows lessons to be drawn between the cities about the process of implementing such travel demand management measures. However, there is still much lack of information in developing countries surrounding measures such as congestion pricing. Politicians are usually wary of a public backlash to the policy from low-and middle-income people who have no option but to drive cars because of limited public transportation access and long distances to work. But this appears to be less of a problem in determining political will in the cases studied. The more significant problem expected is the lack of awareness of the usually affluent car-owning population about the negative impacts they impose on the city, and their unwillingness to accept an extra cost through an unfamiliar policy. Added to this is the lack of awareness about the detrimental impacts of congestion and pollution among the population not owning cars and using public transportation. This can be remedied through appropriate public information initiatives and has been an important lesson of the London Congestion Charging scheme too,

where extensive public information campaigns and consultations were conducted for about 18 months before the start of the scheme.

This research was primarily an exploratory study. However, there is much scope to build on this work through comparative quantitative analyses of economic impacts of the vehicle restrictions and possible congestion pricing schemes for the four cities. If this discussion must progress to a higher level, it must involve an understanding of the relative merits and demerits of different policy proposals, taking into account the quantified costs and benefits to various sections of the population. In addition, a key step for taking this work further is to begin political discussions and public surveys to understand the views of the general public about the problem of congestion, the effectiveness of the vehicle restrictions, and the policy of congestion pricing—communicating clearly about the way the revenues are intended to be used in each of these cities. Designing effective economic policies to manage growing travel demand is important in other large cities of the developing world too where motorization is increasing rapidly because it creates a way for these cities to avoid reaching the unsustainable levels of motorization of many developed countries.

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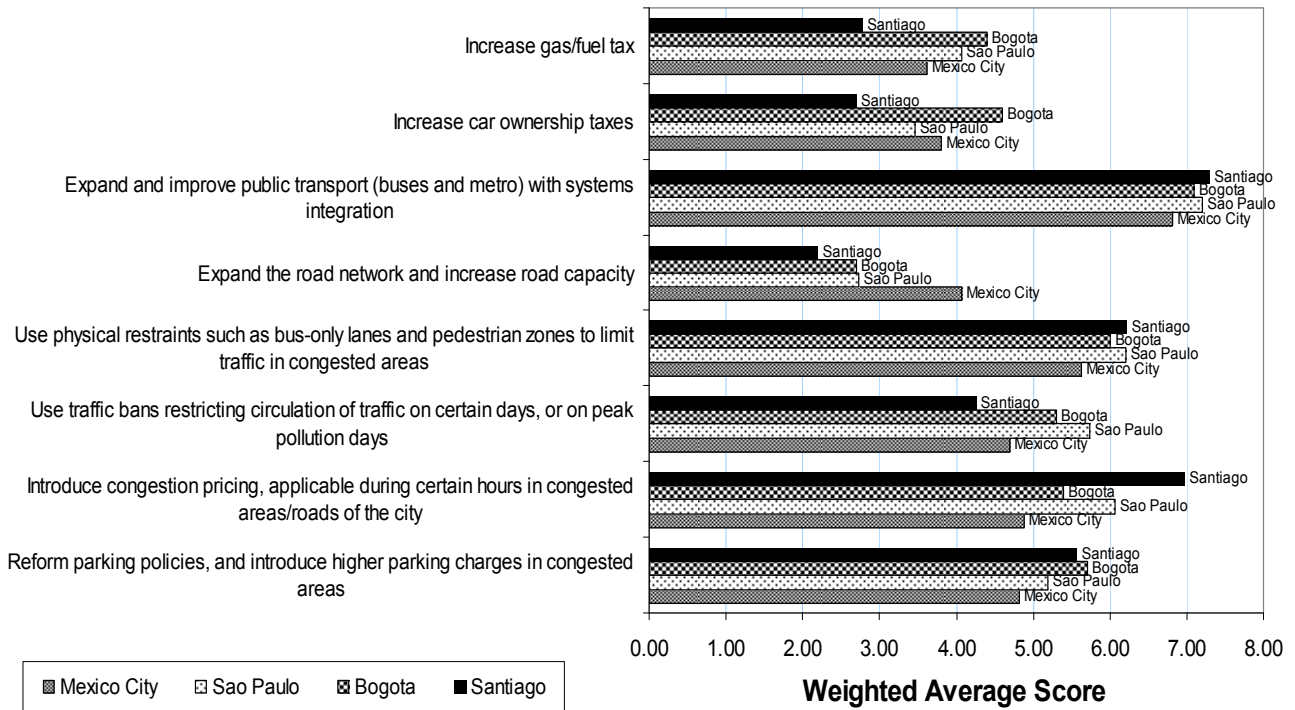
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**Figure 1.**  
**Ranking of Various Policy Options for Managing Congestion in the Surveyed Responses**



**Table 1.**  
**Relevant Indicators for the Four Metropolitan Areas**

Indicators	Bogota	Mexico City	São Paulo	Santiago
Population (millions)	7.7	19.4	18.3	5.7
Avg. annual pop. growth rate (2000-2005)	2.13%	1.44%	1.39%	1.30%
GDP per capita (US\$)	4,125	12,641	6,337	8,475
Urban land area (km <sup>2</sup> )	518	2,072	1,968	648
Population density (inhabitants/km <sup>2</sup> ) <sup>a</sup>	14,900	9,400	9,300	8,800
Automobile fleet (millions)	0.83	2.7	3.4	0.85
Motorization rate (autos/1000 persons)	130	166	184	148
Mode split of motorized trips <sup>b</sup>				
Private motorized <sup>c</sup>	17.0%	23.4%	53.0%	41.0%
Public motorized	83.0%	75.7%	47.0%	52.8%

a Approximate values for average population density have been calculated from most recent available data.

b Totals may not add to 100% for Mexico City and Santiago because combination trips and other trips (as described in the surveys) have been excluded

c Includes taxis

Sources: Automobile fleet, motorization, and mode split data are from the following sources. For Bogotá: *El Tiempo* (2004) and The Bogotá Project (2000); for Mexico City: SETRAVI (2000) and Villegas-Lopez (2000); for São Paulo: CMSP (1998) and DM (2003); for Santiago de Chile, SECTRA (2001). Since the data sources are different and automobile fleet data for Mexico City and Bogotá are only available for 2000/2001, the motorization rate shown above may not be calculated from other numbers in the table.

Urban land area figures for all metropolitan areas are from City Mayors (2007). Population figures are from UN Department of Economic and Social Affairs, Population Division, Urban Agglomerations database (2005). GDP per capita figures are from *América Economía* (2006).

**Table 2. Status of Vehicle Restrictions and Summary of Survey Responses in the Four Cities**

	Bogota	Mexico City	São Paulo	Santiago
Reason for traffic bans	Traffic congestion	Air pollution	First air pollution, then congestion	Air pollution
Success of bans <sup>A</sup>	Successful	Not successful	Successful	Mixed results
Effectiveness of bans towards objective <sup>A</sup>	Decreased congestion	Limited effect on air quality	Decreased pollution and congestion	Limited effect on congestion and air quality
Current response of authorities	Traffic ban considered adequate	Improve Hoy No Circula for better enforcement	Plan for congestion pricing	Road pricing on new roads; future replacement of ban with road pricing possible
Other recent transportation measures undertaken	TransMilenio BRT (2000); increase in fuel tax and parking charges	Metrobus BRT (2005)	Expansion of metro and rail system (2004); bus transport improvements	New toll roads (2006); Transantiago BRT (2007)
Considering congestion pricing	NO	NO	YES	YES

**SURVEY RESPONSES SUMMARIZED**

Number of respondents	10	16	15	40
% of respondents considering congestion a critical problem	70%	100%	87%	20%
Effect of vehicle bans in reducing congestion (% respondents answering positively)	80%	44%	93%	48%
Options to manage congestion <sup>B</sup> <i>Highest ranking</i> (% respondents ranking option first) <i>Next highest ranking</i>	Improve public transport 70% Introduce physical restraints 40%	Improve public transport 56% Introduce physical restraints 31%	Improve public transport 67% Introduce physical restraints 47%	Improve public transport 60% Introduce congestion pricing 50%
Lack of knowledge regarding congestion pricing--% positive responses for option "little public consciousness or information about the policy" **	40%	56%	27%	10%
Is congestion pricing a good way to manage congestion in your city? (% respondents answering positively)	60%	63%	67%	80%

A: Given changes in other factors such as car ownership and income

B: The sum of percentages is greater than 100% because respondents could give multiple options the same rank. The scores for options were weighted accordingly.

\* Options given for managing congestion (also see Figure 2):

- 1) Reform parking policies and introduce higher parking charges in congested areas
- 2) Introduce congestion pricing, during certain hours in certain congested areas/roads of the city
- 3) Use traffic bans restricting circulation of traffic on certain days, or peak pollution days
- 4) Use physical restraints such as bus-only lanes and pedestrian zones to limit traffic
- 5) Expand the road network and increase road capacity
- 6) Expand and improve public transport (buses and metro) with systems integration
- 7) Increase car ownership taxes
- 8) Increase gas/fuel tax
- 9) Other (please specify)

\*\* Options given for level of interest among decision-makers about congestion pricing:

- 1) Little public consciousness or information about the policy
- 2) Not interested
- 3) Somewhat interested
- 4) Very interested
- 5) Already proceeding with scheme proposals
- 6) Controversial and unresolved

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## **PAPER 2**

### **Potential Impacts of Road Pricing on Businesses and Freight Transport: The Case of the Netherlands**

# Potential Impacts of Road Pricing on Businesses and Freight Transport: the case of the Netherlands

## 1. Introduction

Road pricing is receiving increasing attention as a policy option for managing the externalities of road transportation around the world, especially in Europe. The public acceptability of pricing policies has been the subject of much research (Jones, 1998; Mahendra, 2008b; Schade & Schlag, 2003; Viegas, 2001; Wachs, 1995b). The majority of this work has focused on the effects of road pricing on passenger transport and the acceptability of the policy among commuters. But an important stakeholder group that has been relatively less studied in research on road pricing comprises the businesses that drive a region's economy with the goods and services they produce.

Businesses or firms typically form a vocal group that opposes road pricing policies along with passengers, even though they are expected to gain more economic value from travel time savings than passengers (Verhoef, Lijesen, & Hoen, 1998). Some reasons are that firms often do not have transportation alternatives within a region, or they must adopt certain transportation patterns because they face the constraints of location, time-bound schedules for the delivery of goods, accessibility to customers and employees, and relationships with other firms that can limit their choices. Although passenger transport is one aspect of transportation affecting businesses, road pricing is likely to have significant impacts on firms with regard to the movement of goods too. The implementation of road pricing must therefore involve a substantial amount of attention to the development of business impact mitigation strategies that minimize not only economic impacts but also other administrative and implementation burdens of road pricing foreseen by businesses (Whitehead, 2005). These effects relate not only to the firm's economic sector, but also to the type of products it deals in, its location, logistics operations, and the institutional network of which it is a part. Freight transport forms the primary linkage between the transportation system and the functioning of an urban or regional economy. It is therefore critical to understand the impacts of road pricing on businesses that rely on the movement of goods, given their unique institutional contexts.

The high levels of disagreement and opposition within business communities with regard to road pricing must be overcome to ensure that the policy can be successfully implemented (Whitehead, 2002). Questions have been raised about how road pricing is likely to impact economic activity in a city or region, and what incentives might be necessary for it to be more



acceptable and effective for businesses. This research focuses on understanding the potential impacts of road pricing and expected behavioral responses of firms to the policy in the Netherlands, resulting in a conceptual framework and propositions about business response to road pricing. There is considerable literature on the potential impacts of the Dutch road pricing policy on passenger transport and on the distributional impacts of the policy on households<sup>17</sup>. Using data from firms located in the Port of Rotterdam region, I investigate how the implementation of road pricing would affect the accessibility, operations, productivity, and competitiveness of firms in different economic sectors, and the institutional mechanisms through which they would respond to the policy.

### ***1.1. Road Pricing Proposals in the Netherlands and Introduction to the Study***

Proposals to implement road pricing to deal with congestion have been seriously considered in the Netherlands for over two decades but were never implemented due to opposition by various interest groups (Boot, Boot, & Verhoef, 1999), chief among these being business associations and the national automobile owners association. The proposals for road pricing in these years have ranged from peak-hour permits (*'spitsvignet'*), toll plazas (*'tolpleinen'*) and, electronic peak-hour cordon charging (*'rekeningrijden'*) that proposed cordon charges around the four largest cities of the Randstad—Rotterdam, The Hague, Amsterdam, and Utrecht (Boot et al., 1999). The plan for cordon charges around cities, politically approved in 1994, was opposed strongly by the business organizations, private car owners, and political parties. In addition, Rotterdam and The Hague did not agree to participate because of concerns that the cordon charges would have a negative impact on their competitiveness by decreasing their attractiveness for firms and citizens. This finally led to the collapse of the plan (Ten Hacken, 2005).

In 1998, the European Commission (EC) recommended implementing distance-based charging policies in its White Paper on “Fair Payment for Infrastructure Use” (Boot et al., 1999). This spurred attention towards kilometer-based charging in the Netherlands and other countries such as the United Kingdom. In 2005, the Dutch government formally approved policy reform aimed at implementing road pricing based upon the distance driven on the country's highways. The Dutch Ministry of Transport, Public Works, and Water management (henceforth, Ministry of Transport) has proposed the implementation of road pricing for freight transport in 2011 with subsequent charging of passengers to be introduced between 2012 and 2016. The primary

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<sup>17</sup> For a focus on spatial impacts related to passenger transport, see Tillema and van Wee (2002) and Tillema, Ettema, and van Wee (2006). For research focusing on economic impacts on households, see Ubbels and Verhoef (2003) and Verhoef et al. (1998). For research focusing on issues of acceptability and social feasibility of the policy among commuters, see Ubbels and Verhoef (2006).

objective of the policy is to distribute the costs of road usage more equitably among road users. Additional objectives are to manage congestion and improve accessibility, to improve economic productivity, and to overcome environmental concerns. The national road pricing program will cover 134,000 kilometers of all roads and 8 million vehicles throughout the country (Ministry of Transport, 2004). Road pricing with a base price per kilometer is planned for all roads, but the price will vary based on location (higher in busier locations), time of day (higher in peak hours and when congestion levels are higher), and vehicle emissions characteristics (higher for vehicles with higher emissions). The program may start with a flat kilometer-based charge in the initial stage with more sophisticated differentiation of prices coming into effect at a later stage. The program will be revenue-neutral because revenues will be used to replace existing vehicle ownership and sales taxes. As such, the policy has been named “paying differently for mobility” in Dutch and has received political support. Whether or not cordon tolls around the cities will supplement the kilometer-based charges is as yet uncertain. The revenue-neutrality of the proposed Dutch policy and its implementation on a national scale are two features that distinguish it from every other case of implementation of road pricing in the world. In the next section, I discuss the research questions and different theoretical frameworks that may be applied to understand business response to road pricing.

## **2. Research Questions and Relevant Theories**

The research question that this study aims to answer is as follows:

*How would road pricing affect freight-related economic activity in the Netherlands, including the operations and logistics strategies, locations, competitiveness, and organizational relationships of firms in key economic sectors?*

The sub-questions below will help answer the above broader question.

- What factors govern the behavioral responses of firms to road pricing policies?
- How are firms likely to respond to road pricing in the Netherlands?
- How might we classify firms that may be vulnerable to the impacts of road pricing and those likely to gain from the policy?
- How can negative impacts to business activity be mitigated in the design of road pricing schemes?

To understand the impacts of road pricing on firms, I reviewed four main streams of literature: (i) neoclassical economic geography and transportation economics, (ii) business logistics and

supply chain management, (iii) empirical studies and reported impacts of road pricing, and (iv) literature on new institutional economics and organization theory.

### **2.1. Relevant Theoretical Frameworks**

Theories from different streams of literature can be applied to understand the economic effects of an increased transport cost brought about by road pricing. In response to increased transportation costs, microeconomic analysts posit a reduction in trips, change of mode, change of travel time, or change of route through the increased use of alternative free facilities (Button & Verhoef, 1998; Holguin-Veras et al., 2006). Economic geography analysts suggest that firms may decide to relocate, to source products much more from local suppliers, or to only service local markets (Alonso, 1964; Fujita, Krugman, & Venables, 1999; Krugman, 1995; Lösch, 1954; McCann, 2002; Weber & Friedrich, 1929). Some scholars argue that the importance of transport costs in determining firm location decisions has been gradually decreasing as it is becoming increasingly costless in real terms to move goods (Glaeser & Kohlhase, 2004). However, this conclusion does not take into account the importance of the time value of goods in transit and the high sensitivity of certain sectors to time. Even though pecuniary transportation costs have been falling over the years, the sensitivity of firms to time has been increasing (Ministry of Transport, 2004; Muilerman, 2001), given the increasing use of transport-intensive logistics systems such as just-in-time (JIT) scheduling in certain industries. The acceptability of road pricing by businesses in the Netherlands also appears to hinge directly on the perceived time savings that are expected to result from the policy (Barry Ubbels & Verhoef, 2003). In transportation economics literature, research on the price elasticities of demand for road freight transport (Beuthe, Jourquin, Geerts, & Ha, 2001; Graham & Glaister, 2004; Oum, Waters, & Yong, 1992) shows that the values are almost always negative and often exceed unity, implying a relatively high sensitivity to the price of road freight for customer firms. The authors of these studies do caution that estimates differ widely between economic sectors and commodity groups, and also differ by the method of estimation and level of aggregation.

Logistics and supply chain management analysts (Christopher, 2005; Cooper, Innis, & Dickson, 1992; A. McKinnon & Woodburn, 1996) consider a total logistics-cost approach to suggest responses to increased transportation costs that can be expected within supply chains. These include operational, tactical, and strategic decisions made by firms in the short, medium, and long-term (Cooper et al., 1992). Firms are embedded in networks of supplier and customer relations comprising flows of raw materials, intermediate goods, and end products (Hansen, 2004). They make logistical choices about contracting out transportation operations to carriers

versus managing their own transport, using just-in-time operations versus substituting transportation intensity with increased warehousing capacity, and other decisions about how their production and distribution is organized. Not only would firm responses to road pricing differ substantially by sector and product type, but also by whether a firm is a shipper, carrier, or receiver of goods. The percentage of a firm's sales revenue that is represented by road transport costs and the stage at which a firm operates in its supply chain are also factors that could determine behavioral response to an increase in the price of freight transportation (McKinnon and Woodburn, 1996). Firms may pass on the increased costs to customers or absorb them by increasing their own efficiency and altering the way they do business. Some firms have a high share of transport costs relative to total production costs, others require high levels of speed and reliability in the delivery of goods, and some have low turnovers or profit margins such that a small increase in costs may have a significant impact on their business.

Empirical studies also offer some guidance on the effects of road pricing. So far within Europe, Switzerland, Germany, and Austria have implemented road pricing for goods vehicles based on the distance traveled. McKinnon (2006) discussed the observed effects of these truck-tolling policies in detail. In all three countries, the truck tolls have increased road freight rates significantly. However, these schemes differ from the proposed road pricing policy in the Netherlands in important ways: (i) they do not include all vehicles as the Dutch policy does; (ii) the charges do not vary by time of day and location, and (iii) the revenues are not used to reduce taxes for vehicle operators. From a recent comprehensive survey of freight carriers in the New York and New Jersey metropolitan area, Holguín-Veras et al. (2006) report the variety of behavioral responses to the road tolls introduced at six bridges and tunnels in the area in 2001. Two hundred for-hire and private carriers were surveyed, representing 1,271 truck trips in the region. From this sample, about 20% of carriers changed their behavior in response to the road pricing initiative. In 43% of trips, these carriers implemented changes that increased their productivity and efficiency, while they were able to transfer the costs of road pricing to customers in only 9% of the trips (Holguin-Veras, 2006). Of the 80% of carriers that did not change behavior, over three-quarters mentioned that they had no choice in the matter, and they either had to use the quickest route or to adhere to schedules provided by customers.

These interesting results establish two contrasting possibilities about the impacts of road pricing on firms in the transportation sector. One, the freight carriers' responses show that the balance of power is largely in favor of the customer or shipper, and there is considerable inflexibility in changing operations. This implies that transportation carriers are compelled to absorb the increased costs. By making operational changes, carriers seem to shield customers

as far as possible from cost increases. Two, and in contrast to the above results, Verhoef et al.(1998) analyze the aggregate economic impacts of the planned introduction of road pricing in the Randstad area and conclude that the transport sector would by far be the “net winner” through gains in efficiency and travel time savings from a road-pricing policy.

New institutional economics and organization theory analysts take into account the organizational relationships between firms, the power and dependence relations between them, the institutional environment that firms are a part of, and the transaction costs associated with institutional change. Through the mechanism of price (increase), the key objective of road pricing is to alter travel behavior. This would involve a change in institutions, per Douglass North’s (1994) definition of institutions as a set of rules, laws, conventions, behavior norms, and their enforcement characteristics (North, 1990, 1994). Although formal laws can rapidly be changed through political decision, individual actors may not perceive, accept, or understand these changes immediately. Informal rules take longer to change and may change in a manner that is incompatible with initial objectives. North (1990) describes this phenomenon as follows: *“Institutions change, and fundamental changes in relative prices are the most important sources of that change. To the noneconomist (and perhaps for some economists as well), putting such weight on changing relative prices may be hard to understand. But relative price changes alter the incentives of individuals in human interaction...”*

Several strands of new institutional economics (Coase, 1960)<sup>18</sup> are applicable when examining road pricing as a solution to the externalities of transportation, especially in the context of firms. Given that a firm is an economic organization (North, 1990), the literature on organization theory that is considered a part of new institutional economics (International Society for New Institutional Economics) is also relevant. The organizations that come into existence and how they evolve are fundamentally influenced by the existing institutional framework, and they, in turn, influence how the institutional framework evolves. The responses of firms to road pricing that I am interested in studying are, in essence, adaptations by firms to their institutional environment. Organization theorists who have studied how organizations adapt to their environment have researched the role of inter-organizational power. Also, (Cox, Ireland, Lonsdale, Sanderson, & Watson, 2002; Ireland & Webb, 2007) have specifically discussed the concept of power in buyer-supplier relationships and in supply chains. The

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<sup>18</sup> Pigou’s well-known ideas on the taxation of externalities to force a change in behavior were challenged by Ronald Coase (1960) in his seminal article “The Problem of Social Costs” in which he discussed the effects on firms. Coase’s main point was that the price mechanism can be used to resolve the problems of social costs or externalities in a hypothetical world of zero transaction costs assumed by Pigou and other economists in the Pigovian tradition. However, this may not be the most desirable arrangement in the real world where transaction costs are always positive, especially where an adaptation of institutions is involved.

definition of power in this context comes from the theory of resource dependency where the relative power of one organization A over another organization B arises from the net dependence of A on B (Emerson, 1962; Pfeffer & Salancik, 1978, 2003). This means that if there is a dependence asymmetry between organizations, there is a power difference, and some organizations would enjoy an influence over others that they do business with (Emerson, 1962).

The resource dependency theory (Emerson, 1962; Jacobs, 1974) states that the dependence of one actor on another is a function of two variables: the *essentiality* of a resource and the *substitutability* of a resource. If firm A controls a resource (product or service) that is essential or indispensable for B, then B depends on A. If there are many other suppliers available who can substitute for A in providing the same resource to B, then B will be relatively less dependent on A. These power relationships in a supply chain are transaction-specific and despite the power differential, contracting parties always have some measure of mutual interest between them. Firms cannot perform all tasks themselves because they are inherently resource-constrained, and must procure the goods and services that they are not capable of supplying themselves (Cox, et al., 2002). Therefore, firms are interdependent and this interdependence has increased over time as firms become more specialized (Pfeffer & Salancik, 1978). The resource dependency theory has been important in the social sciences and economics. However, it has received minor attention in the literature on supply chain management (Cox et al., 2002) and is found to be relevant in the buyer-supplier relationships between firms. The next section describes the research methodology for this study.

### **3. Research Methodology**

Few past studies have collected data on the responses of firms to road pricing scenarios that focused not only on the responses but also on how and why they occur. Therefore, because my aim was to explore a relatively less researched topic, I considered a stated preference approach using semi-structured face-to-face interviews to be the best method of data collection. Surveys involving stated preference methods to study behavioral responses in hypothetical situations (Louviere, Hensher, & Swait, 2000) have been commonly used in transportation research. The advantage of face-to-face interviews is that they provide a high level of depth and detail of information (Emory, 1985). I was also able to obtain further clarifications to the interview responses when necessary to ensure proper interpretation. However, response bias may occur

in the form of strategic answers or incapability on the part of respondents to reflect fully on the impacts of road pricing, especially in the long-term

### **3.1. Choice of site**

The firms where I conducted interviews are located in and around the Port of Rotterdam in the province of South Holland in the Netherlands. Rotterdam is part of a high-density metropolitan region known as the Randstad in the western part of the country, bound by the country's four most highly populated cities—Amsterdam, Rotterdam, The Hague, and Utrecht (Europe, 2001; VROM-Raad, 1998). This is often regarded as a single metropolitan region with 8.5 million inhabitants, encompassing over half the population of the Netherlands (Randstad, 2007). The region has great economic and strategic importance in the Netherlands and is interesting to study for at least two reasons. First, the Port of Rotterdam is the largest port in Europe (Lakshmanan, 2001) and the third busiest seaport in the world after Shanghai and Singapore, based on cargo tonnage (AAPA, 2005). The port thus has a major impact on the transportation system in the region. Second, the high density of the region leads to significant traffic congestion in peak hours.

According to the Ministry of Transport (2004), congestion in the Dutch road network is highest in the urban areas of the Randstad region, especially on the key highways linking the port with the rest of the country, and it is expected to rise (Ministry of Transport, 2004). From the port to the mainland, there exists a single congested highway link (the A15 highway), which is critical in view of the impending expansion of the port. Most goods destined for European markets are primarily imported and distributed through Rotterdam. The region's economy depends heavily on transport and logistics, for which improved accessibility and minimized travel delays are important requirements. The heaviest road transportation flows in Europe are those between Germany and the Netherlands at around 40 million metric tons in each direction in 2005, reflecting the major role of the Port of Rotterdam (Eurostat, 2005). Germany already has a distance-based charge called the Maut (toll) in effect for heavy-goods vehicles (see details in McKinnon, 2006), the impacts of which were being faced by some of the Dutch firms that I interviewed.

The Netherlands has long been a trading nation supporting a high level of international freight in transit through the country. Transportation and distribution services provided by Dutch logistics firms for goods received in the Port of Rotterdam add value to the region's economy. Freight traffic on Dutch roads is expected to grow by about 70% between 2000 and 2020 leading to \$770 million per year (€500 million) in direct costs of travel delays for goods

transported by road—an increase of two and a half times from the year 2000 (Ministry of Transport, 2004).

### **3.2. Selection of firms and recruitment of respondents for interviews**

To select firm managers for the 21 in-depth semi-structured interviews that I conducted in Rotterdam, I sampled firms that depended on freight transportation, varied by sector and size, and represented sectors that were important in the Dutch economy. In addition, I conducted two interviews at key Dutch organizations representing businesses (EVO and TLN, Transport and Logistics Netherlands) and about 10 interviews with government officials, academics, and transportation experts<sup>19</sup>. This fieldwork was carried out in October and November 2006, with the support of the Faculty of Technology, Policy, and Management at the Delft University of Technology (TU Delft) and the Netherlands Organization for Applied Scientific Research (TNO). I conducted the interviews with the help of a Dutch masters degree student from TU Delft who was doing research on a related topic. I designed the questionnaire and we shared the work of preparing the 21 transcripts. Fifteen interviews were conducted in English and 6 were in Dutch because the respondents were more comfortable in their native language. I had the transcripts that were in Dutch professionally translated. For the interviews, I selected firms based on three criteria—

(i) *Significance of the sector in the Dutch economy at different scales, measured by its contribution in terms of Gross Value Added (GVA)*. I used this criterion to ensure that the research focused on sectors that were important in the Dutch economy. From the Dutch national and regional input-output tables available from Statistics Netherlands, I obtained the 2003 GVA values for each sector. I identified the common sectors from among those that ranked highest in terms of GVA at national, regional, and local scales. At the regional scale, I used data for West Netherlands and the province of South Holland; and at the local scale, data for the Rijnmond (Rhine estuary) region that includes the city of Rotterdam as its economic center. Because my interviews were to be conducted in Rotterdam but the Dutch road pricing policy is a national policy, it was essential to include sectors that were important at all geographic scales and to ensure that critical sectors were not excluded from the analysis.

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<sup>19</sup> Approval from the MIT Institutional Review Board, the Committee on the Use of Humans as Experimental Subjects (COUHES), was obtained prior to conducting the interviews.



(ii) *Dependence of the sector on road-based freight transportation, based on product characteristics and freight flows* (data obtained from TNO and TLN, Transport and Logistics Netherlands). Given the aim of my study, it was important to sample firms that had a high volume of freight flows, time-sensitive operations, or both. Certain product attributes, such as value density, perishability, and the need for high reliability due to the product being an intermediate input into further manufacturing processes may lead to different responses to road pricing even for firms in the same broad sector. For example, in the wholesale and retail sector, which was one of those I selected, I included a variety of firms in the sample, such as those involved in the sale of household goods, flowers, furniture, and metal, to assess the role of product attributes in the firm's potential response to road pricing. To use the example of product value density, if transport costs are a small proportion of the total costs of a firm dealing in a high-value product, then I would expect to see a lower impact as compared to a firm dealing in lower-valued goods whose transport costs represented a relatively higher proportion of its overall costs. I omitted sectors such as financial, insurance, and real-estate services, though important, because their operations typically did not involve much freight transport.

(iii) *Size of the firm, measured by the number of employees*. Firm size is an indicator of the resource strength of a business. Research on how a firm responds to changes in its environment has emphasized the salience of firm size. A large firm may be better able to absorb the increased costs of road pricing than a smaller firm. Although firm size can be conceptualized in terms of employees, scale of operations, or market share, empirically, analysts expect these variables to be related (M. Chen & Hambrick, 1995). Empirical research on different industries has shown that firms of different sizes perform differently and need different strategies to maintain their competitiveness. Compared to larger firms, smaller firms face greater pressures that threaten their survival, suggesting that small size may be a liability (Goll, Johnson, & Rasheed, 2006).

Based on the above criteria, I selected the following sectors for representation in the interviews:

(i) food and beverages, (ii) transportation and freight forwarding, (iii) wholesale and retail, (iv) construction, and (v) chemicals. Within these sectors, I contacted firms listed in the Port of Rotterdam business directory and selected a sample of 21 firms based on the willingness of key personnel to participate in the interviews. In each firm, the selected respondents were either managers in charge of the transportation and logistics functions of the firm or were managing directors in the case of smaller firms. I first approached the firms by telephone to confirm

whether they met the selection criteria and to make appointments with the person most likely to have thorough knowledge of the firm's transportation and logistics operations. Finally, I conducted interviews lasting about one hour with all respondents. Table 1 shows the number of firms of each size selected from the different sectors.

## **TABLE 1 ABOUT HERE**

### ***3.3. Design of interview questionnaire and scenarios***

My literature review led to a preliminary assessment of factors that may play a role in determining the responses of firms to road pricing. It also provided a starting point for the design of the interview protocol comprising open-ended questions that was used in the field to interview firm managers. I started with four preliminary propositions, expecting to determine from the interview data how and why the following impacts might occur.

- (i) The impacts of road-pricing policy will differ by business sector.
- (ii) The impacts will differ by business size: smaller firms would find it more difficult to cope with an increase in costs.
- (iii) The location of firms is an important factor that will affect response to road pricing.
- (iv) The design of the road pricing policy would affect business response to the policy.

I prepared four scenarios of road pricing to elicit responses from the firms to different policy designs. The scenarios differed in the level of the charge and consequently, the expected level of congestion reduction, the criteria of differentiation, the area of coverage, and the use of revenues. The four scenarios were: (1) the proposed distance-based road pricing policy with charges differentiated by location and time of day; (2) environmentally focused road pricing with higher charges for vehicles having higher emissions; (3) charges on a dedicated lane of the A15 highway, varying by vehicle weight; and (4) cordon charges to access the four cities in the area in addition to distance-based pricing on the highways. In 2006 when I conducted this research, the design of the Dutch road pricing policy was not yet finalized. The policy furthest along in the decision-making process and most likely to be implemented involved a distance-based charge of approximately 11 euro cents (approximately US\$ 0.17)<sup>20</sup> per kilometer on all roads in the nation. The charge would be differentiated by the time of day when a vehicle was driven, the location, and possibly the emissions characteristics of the vehicle. Thus vehicles driven during peak hours, in congested locations, or having higher levels of

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<sup>20</sup> Currency conversions are obtained from the March 16, 2008 Universal Currency Converter available on the website <http://www.xe.com/ucc/>.

emissions would pay a higher charge. As of spring 2008, the actual charge per kilometer is still tentative. This policy was used as the basis of Scenario 1 in the interview questionnaire. The scenario included differentiation of the charge by time and location but not emissions characteristics as this was still tentative.

I based Scenario 2 on the existing design of the Swiss and German road pricing schemes where charges for heavy-goods vehicles are differentiated solely by the environmental impact of the vehicles in terms of emissions. The relatively high level of the charge specified in this scenario is similar to that currently in effect in Switzerland (Mckinnon, 2006). I based the third scenario on independent proposals that were part of the Dutch Transumo project, to introduce a dedicated tolled lane for vehicles on the A15 highway—the main corridor connecting the Port of Rotterdam with the rest of the country. As part of the Dutch road pricing proposal, there were also suggestions to have urban cordon charges, such that vehicles paid an additional charge for circulation within the central areas of the four large cities of the Randstad region in addition to, or independently of, the national kilometer-based charge. This feature of the policy is as yet undecided in the spring 2008, but I used it as the basis for Scenario 4 in the interviews. I also included in the scenarios different ways of using the revenues on which respondents could comment. The four scenarios are described in Table 2. Due to time constraints during the interviews, I focused most extensively on Scenario 1, which is closest to the current road pricing scheme proposed in the Netherlands.

## **TABLE 2 ABOUT HERE**

Tables 3 and 4 show the themes of questions that were discussed in the interviews. One of the limitations of asking questions about an emotive issue such as road pricing is that the responses could be biased due to perceptions of negative (or positive) impacts from the policy. I included several background questions in the interviews to check for consistency and to ensure the validity of responses to the road pricing scenarios. Table 3 describes the categories of background and contextual questions about the firm and the respondent, characteristics of the firm's product and market, the firm's supply chain characteristics, aspects of its transportation operations, and sectoral trends in terms of prior adaptation of operations, changes anticipated in the future, and the level of preparation to deal with these changes. Table 4 shows the categories of questions that I asked to understand how firms would respond to each of the four road pricing scenarios and what impacts were expected. In line with the research question, I asked firms about potential impacts on their transport operations and

logistics strategy, location decisions, costs and competitiveness, relationships with other firms, and finally, about their acceptability of road pricing. I prepared two slightly different questionnaires for carriers, i.e., transport firms, and for shippers, i.e., the customers of transport firms. In the next section, I present the findings from the interviews.

**TABLE 3 ABOUT HERE**

**TABLE 4 ABOUT HERE**

#### **4. Findings from the Data**

The data I obtained included not only stated responses of firms to the hypothetical scenarios, but also revealed responses if the firms had already been experiencing any other European road pricing policy. In the latter case, firms located in Rotterdam had most commonly experienced the German Maut in their operations, but felt that they could pass the charge on to German customers because, in the words of one respondent, *“it is their invention, not ours”*, implying that it was logical for German firms to compensate Dutch firms for the Maut. One firm in the sample also experienced the London congestion charge regularly. I first discuss the contextual background of each sector, followed by the responses of firm managers.

##### **4.1. Contextual background of all sectors**

The first part of the questionnaire provided detailed insights into the operations, institutional environment, and market trends of sectors from which firms were selected for the interviews.

###### **4.1.1. Chemicals manufacturing sector**

The Port of Rotterdam is an important chemical cluster in the European Union. The chemicals sector is the Netherland’s second largest industrial sector after food and beverages. In 2002, it represented about 15% of the industrial output of the country and 20% of total Dutch exports (Netherlands Foreign Investment Agency). Within the EU, the country leads in all chemical industry sub-sectors, including petrochemicals, polymers/plastics, man-made fibers, industrial chemicals, paints and coatings, fine chemicals, and performance chemicals.

Five firms from the chemicals sector were included in the interviews. All firms relied on road as the primary mode of transport for shipping within the Netherlands and to adjacent countries. Firms in this sector considered transportation attributes such as reliability and the flexibility to make changes at short notice more important than cost in their transport decision-

making. High reliability is important because many firms have just-in-time operations. Many customers can only accept a truckload of the product at one time; they do not have much storage, and it is therefore essential that they do not run out of material during production. Some common characteristics of all these firms are that they: (i) face a high level of price competition and demand in their markets, (ii) ship intermediate products that are a direct input into the production process of another manufacturer; (iii) depend on a high frequency of transportation because of the sectoral trend towards keeping the levels of stock as low as possible; (iv) only produce what the market demands and deliver it quickly and frequently to customers because many of the companies are small to medium in size; (v) on average have relatively low transport costs—from 2-10% of the total production costs—but much higher indirect logistics costs of delays and lost or damaged shipments; (vi) typically outsource their transport, because they require specialized vehicles, and they pay the transport costs of delivering products to their customers; (vii) must follow strict environmental, health and safety regulations for which they rely on trained, certified drivers, and there is currently a shortage of these drivers in the market (viii) face difficulties in meeting the reliability requirements, because delivery times are set by customers and congestion-related delays are inevitable at certain times of the day. Demands on service quality are expected to increase in this sector in the coming years.

#### 4.1.2. Transportation sector

In my interviews, I encountered a commonly held view that profit margins in the transportation sector are low because operators were willing to do business even at cost price if it meant that expensive vehicles did not have to stand still and depreciate. Given the rising costs of fuel and congestion, along with a higher focus by shippers on reliability, flexibility, and just-in-time delivery of goods, there is a growing trend towards increased formal and informal collaboration and subcontracting among transportation firms, in order to improve operational efficiency. The five firms in the transportation sector where I held interviews differed in the products they specialized in. All respondents mentioned that they face costs due to traffic congestion. A firm that transported construction materials and another that transported liquid chemicals depended heavily on speed and reliability because of their customers' use of just-in-time operations. In both these sectors, specialized transportation vehicles were used, typically implying that firms could charge customers for the full and empty runs of the vehicles. Common challenges that firms in this sector faced were high levels of competition, a shortage of drivers, the increasing influx of cheap labor from new EU-member countries such as Poland, and restricted time

windows to deliver goods into the cities or to pick up goods at the port, forcing them to drive within peak hours in congested conditions. Two interviewees emphasized the recent trend wherein smaller transport firms are disappearing because they cannot compete with larger firms. They either get incorporated into larger firms or sustain themselves from a fixed group of customers in a niche market. All five firms had experience shipping goods to Germany and discussed their response to the German Maut policy. All transport firms had passed on the charge for the Maut to customers as well as any increase in fuel price.

#### 4.1.3. Wholesale and retail sector

In the wholesale and retail sector, I conducted interviews at six firms. The firms traded in products that differed in value and sensitivity to time, such as metals, cut flowers, fruit, produce, and household goods. A common characteristic of all firms was the importance of service reliability in their operations, due to two reasons. First, these firms were bound by strict time schedules due to restricted time windows for loading and unloading products at the retail outlets they delivered to. Second, the large retail firms made multiple trips in a day to distribute goods to their shops on a just-in-time basis because of the tendency of retailers and supermarkets to keep low stocks. Although reliability was considered an important requirement for transportation, half the respondents mentioned having no choice but to suffer travel delays from making deliveries during peak hours because of fixed time windows for delivering goods stipulated by local governments. Small firms, especially, had no choice but to drive in peak hours because they had to use their vehicles to the greatest extent possible.

Transportation was contracted out to carriers by four out of the five firms because the costs of driving a partially loaded truck are too high. Transportation firms could efficiently group shipments for different customers to ensure a full truck load. Also, for firms dealing in perishable and time-sensitive products, such as flowers and produce, speed and transit time are of greatest importance. Because these are fast-moving goods that had to be replenished every day, if the shipper missed the time windows for delivery due to delays, then a day's loss would be incurred. The firms dealing with flowers and fruit required specialized transport and their products were relatively low in value, making the transportation costs quite significant as a proportion of product value. In addition, price competition was extremely high especially in the case of supermarkets and the fruit wholesalers who shipped to supermarkets. Profit margins in this sector are also much lower than average. Thus, a rise in transport costs could potentially reduce profitability.

#### 4.1.4. Construction sector

Two of the interviewed firms fell in the broad category of the construction sector—one was a small firm that designed and manufactured furniture and another was a medium-sized sand wholesaler for the construction industry. The furniture manufacturing firm had its own vehicles and congestion was an inconvenience, but the firm had no other options to change operations. It charged customers for the transport and time costs of delivering products. The manager of the sand wholesale firm, on the other hand, mentioned that the market had a tradition of competitive cartels and was driven by price. The firm's customers were typically Dutch construction contractors from around Rotterdam. This firm also had its own vehicles and considered it important to control its transportation because it sold a low-value product with transportation costs being a significant proportion of product value. The firm could provide a better level of service at a lower cost than transport operators with its own vehicles. Congestion-related delays were taken into account when fixing the transport rates because the firm had no choice about delivery times, which were always dictated by the customer.

#### 4.1.5. Food and beverages manufacturing

The three firms where I held interviews in this sector were all large firms. One firm was a manufacturer of spices and sauces, another firm manufactured intermediate products for the food and beverages industry, and the third firm manufactured beer. Similar to other responses, respondents from two of the three firms mentioned that requirements for just-in-time delivery and reliability were high because of a trend to keep stocks as low as possible and because customers had their production cycles running. Some customers did not have the flexibility of more than an hour or two before their production needed to stop. Two firms contracted out their transport and the third firm had its own vehicles. Transportation costs represented about 5-10% of product costs.

### **4.2. Responses to Road-Pricing Scenarios**

When asked to respond to the scenarios, the majority of interviewees expressed skepticism regarding the congestion reduction expected from road pricing. They explained that because higher fuel charges had not led to reduced congestion, they did not expect the kilometer-based charge to have any significant effect. Some of the manufacturing firms knew that they would increase their capacity in the near future and so would other firms in their sector; therefore no reduction in congestion could be expected, because it would be offset by a growth in freight traffic. Twelve of the 21 firms were also facing the German Maut charge for goods that they

shipped to Germany, and were thus able to discuss their responses to that charge. I organize the responses to the scenarios into the following four categories based on the research questions: (i) operations and logistics; (ii) location decisions; (iii) costs and competitiveness; and (iv) organizational relationships. Examples of responses relevant to each of these categories that were mentioned in the interviews are shown in Table 5. In the next section, the responses for Scenario 1, based on current proposals of the Dutch government, are explained in detail. Responses to Scenarios 2, 3, and 4, are mentioned separately.

## **TABLE 5 ABOUT HERE**

### **4.2.1. Responses related to Operations and Logistics**

Operational responses to road pricing involve exploiting relatively lower-cost options to increase efficiency. They are the ones that have been most commonly studied by analysts (Golob and Regan, 2000; Holguin-Veras et al., 2006) and have been observed as a result of truck tolling policies elsewhere in Europe (McKinnon, 2006). These responses include attempts to change routes, to reduce the frequency of trips or the distance traveled, to increase vehicle utilization by a higher level of loading or consolidation of goods, and to change travel times. Changing travel times could involve avoiding travel during peak hours and negotiating with customers to change delivery schedules. Finally, in policies such as the Swiss and German pricing schemes, similar to Scenario 2 in the interviews where the charge paid by a vehicle is differentiated by its emissions characteristics, switching to cleaner vehicles in order to be exempted from the charge can also be described as an operational response. Table 6 lists the operational responses mentioned by managers of firms in different sectors, the challenges they would face in implementing the response, and possible solutions that must be considered along with plans to introduce road pricing.

## **TABLE 6 ABOUT HERE**

### **4.2.2. Responses related to Location Decisions**

These include responses related to firm location and accessibility. A spatial response could involve changing locations of the firm's premises, retail outlets, or the locations of warehouses and distribution centers. For example, firms may consider changing their location if they suffer from accessibility impacts related to an urban cordon charge. These responses could also involve decisions about location over the entire supply chain, for example, decentralization of



inventory to hubs that are located closer to customers in order to reduce transportation costs. Overall, location change was not a likely response to road pricing due to the high capital investments involved in changing locations of factories and other premises. The locations of sources of supply and customers also determined the current location of firms. Although location changes may not be likely at the local scale, they could be possible for firms having international operations. One of the respondents from the chemical sector mentioned that his firm may shift production elsewhere because it would be “*knocked out of competition*”, unless road pricing was implemented all over Europe. Another respondent from a large chemical firm gave a similar response, saying that location decisions for the future could depend on this policy, because it was the global picture of their operations that was important, not simply the operations in the Netherlands. These may have been strategic responses because it appeared that local advantages such as the presence of industry clusters (e.g., in the chemicals sector), the availability of the product, proximity to the port, and the availability of an urban market area (in case of transportation, construction, and retail and wholesale firms) were important reasons for firms to locate in a particular region. Table 7 shows expected responses related to location changes, challenges, and possible solutions mentioned by the respondents.

## **TABLE 7 ABOUT HERE**

### **4.2.3. Responses related to Costs and Competitiveness**

In this category, I include responses through which the firms could avoid the impacts on their profitability and competitiveness. These impacts could occur as a result of a firm’s relationships with other firms, with customers, or due to external factors such as existing regulations or market conditions that exacerbate the impact of road pricing. For instance, two respondents mentioned that road pricing would threaten their competitiveness and the policy “*moves away from a level playing field*” compared with their competitors elsewhere in Europe. According to a respondent:

*“It is a threatening scenario because for companies who want to invest in the Netherlands, the country is already very expensive. If you further charge this 11 cents per km, then companies will not be interested in investing here.”*

When a firm faces higher costs due to road pricing, it may or may not also experience the benefits of reduced congestion and higher productivity, or, as in the Dutch case, a reduced level of vehicle taxes. In case of higher net costs, a firm can either bear the increased costs or pass them on completely or partially to customers. A firm may also decide to split the costs with

other firms that it does business with in its supply chain, before they reach final consumers. Firms that hire transportation carriers may demand higher levels of service from the transport firms. Transport firms may receive net benefits from the policy because of reduced vehicle ownership taxes, higher reliability leading to greater utilization of vehicles, and the ability to pass on the costs of road pricing to their customers. For example, an interviewee from a small chemical firm said:

*“What can we do? We cannot refuse a higher price to carriers because the product has to be transported. We don’t have a choice. I am not sure if [transferring prices to customers] is possible.”*

Some firms may experience negligible cost-related impacts because of one or more of these reasons—they have fixed prices, work on the basis of fixed commissions, the transport costs are insignificant in their operations, or they have high influence in passing on the charge due to their large size or specialized products. Table 8 describes these responses.

## **TABLE 8 ABOUT HERE**

### **4.2.4. Responses related to Organizational Relationships**

The conventional ways in which firms have operated in order to meet their objectives and the organizational relationships they have formed constitute their institutional environment. Firms could change their organizational relationships in order to eliminate the increased costs of complying with road pricing. For example, firms may subcontract or outsource a higher portion of their transport operations rather than carry out those operations themselves. On the other hand, some firms that have been contracting out transport operations may decide to reduce the uncertainty and information asymmetry regarding actual distances traveled, loads carried, and net transport costs by choosing to do more of their transport operations themselves. This is important because many transportation firms operate with fixed rates, thus reducing the transparency and customer control over transport costs. Firms may establish horizontal cooperative relationships with other firms in their sector or location, or vertical cooperative relationships with firms that are their suppliers or customers, in order to share the higher costs or to find ways to compensate for them. If shippers believed that the reduction in congestion expected from road pricing was possible, they may negotiate with transport firms to provide a higher level of service and reliability in exchange for the higher costs that would be passed on to them. More broadly, firms may renegotiate contracts with customers and suppliers, or even change the customers, suppliers, and transport companies with whom they do business. A firm

may also decide to make no changes to its operations or business relationships if it is able to pass on all costs to customers or if it can absorb the increased costs from transport companies. Table 9 lists these responses, challenges to implementing them, and possible solutions.

## **TABLE 9 ABOUT HERE**

### ***4.3. Responses to Scenario 2***

Responses to Scenario 2 (environmental scenario) can be distinguished according to firms that owned their vehicles and those that contracted out their transport operations. The large transport firms and other large firms that owned their vehicles would speed up the replacement of vehicles to cleaner ones and pass on the costs to customers. Large firms in other sectors such as food and beverages manufacturing and retail mentioned that they would expect their transport firms to switch to cleaner vehicle fleets. Thus, the use of vehicles emissions as a differentiating characteristic for road pricing may help speed up the transition to cleaner vehicles. The smaller firms that owned their vehicles mentioned that the costs of changing vehicles would be significant and they would not be able to pass them on to customers. A respondent from a small transport firm mentioned that he would consider other solutions such as changing driving times if possible. Small firms that contracted out their transport operations did not think that they were in a position to demand the use of cleaner vehicles from transport firms but expected that transport firms would change vehicles anyway in order to be exempt from the high charge. They believed that those costs would in part be passed on to them.

### ***4.4. Responses to Scenario 3***

The majority of firms that used the A15 highway and had operations in the port area mentioned that they would use the dedicated toll lane for higher reliability and speed, especially when they were shipping goods just-in-time. The costs would be passed on to customers if they demanded deliveries at times when the tolls were in effect. Two firms mentioned that higher charges based on higher vehicle weight would make their operations very expensive because they loaded their vehicles to the maximum weight possible. Respondents generally did not expect that travel delays on the A15 highway could be reduced by the use of a dedicated lane due to the high volume of freight traffic on that highway.

#### **4.5. Responses to Scenario 4**

Interviewees from the wholesale and retail firms had strong responses to Scenario 4 (urban scenario). These respondents mentioned that they would face very high costs from an urban cordon charge because most of their deliveries were made to shops and restaurants in the four cities. They mentioned that in this case it was unavoidable to pass on the charges to consumers. These firms were already facing several municipal restrictions for supplying goods to the cities, including limitations on vehicle sizes, permit requirements, and more importantly, restrictions on delivery times. Respondents explained that they had very tight time windows to unload goods and some districts were planning to increase this constraint by tightening the time windows further. They mentioned that if retail outlets have to be supplied fast and with minimal inconvenience, then city centers must remain accessible. Firms in the construction sector and some transportation firms also had to deliver goods to customers in the city centers. They would thus have to pay for the urban charge and would pass it on to their customers.

#### **4.6. Revealed response to German Maut**

Of the 12 firms that delivered goods into Germany, all five transportation firms and two firms that manufactured chemicals had passed on the costs of the German Maut to their customers, although some mentioned facing problems with customer acceptance. Two of the firms were only paying a part of the costs for the Maut, and three firms were paying the full costs. These responses of firms to the German Maut charge provided some indication of possible responses to the Dutch road pricing policy as the level of the charge is similar; however the German charge does not vary by time of day but rather by vehicle weight and emissions characteristics.

Table 10 shows the responses of all firms related to operations and logistics, location decisions, costs and competitiveness, and organizational relationships. Upon analyzing the firms' responses to the four scenarios, specific factors emerged important in understanding why firms with certain characteristics would respond in certain ways.

**TABLE 10 ABOUT HERE**

## **5. A Conceptual Framework of Factors Affecting Firm response to Road Pricing**

I analyzed the interview data to develop a conceptual framework of factors governing business responses to road pricing and the types of responses that were likely to be exhibited. Using the methods of grounded theory (Charmaz, 2000; Corbin & Strauss, 2008; Strauss & Corbin, 1997), I did this as an iterative process of identifying emerging themes by constantly comparing across the interview transcripts, and validating the importance of emerging concepts through literature. Theories from literature and the results from empirical studies were used to formulate the preliminary propositions that a firm's response to road pricing could be explained by factors such as firm size, sector, location, and the design of the road pricing policy. My literature review showed that institutional variables such as the regulatory environment and market power of the firm were also critical factors, although the relationships between the variables were unclear. Data from the interviews provided evidence that firm responses to road pricing were also linked with the level of specialization of the firm, its bargaining power in the supply chain, the type of customer, horizontal and vertical relationships with other firms, and the regulatory constraints the firm faced in its institutional environment. The conceptual framework I developed is shown in Figure 1 and elaborated below.

### **FIGURE 1 ABOUT HERE**

#### **5.1. Independent variables -- Firm-specific factors**

A key finding from the interview data was that firm, size, sector, and location do have an effect on how firms respond to road pricing; however, the causal impacts of these *independent* variables would, in fact, occur through institutional factors that act as *intervening* variables. I discuss below the role that both these sets of variables play in determining how firms may respond to road pricing in the Netherlands.

##### **- Firm size**

The importance of firm size was not explored much in the literature, but McKinnon (2006) alludes to the challenges that may be faced by small transport firms. Firm size, measured in terms of number of employees, number of locations, or scale of operations, proved to be important in determining the market power of a firm, the impacts of the increased costs from road pricing, the extent to which it can absorb increased costs, and the extent to which it can pass costs on to customers. Larger firms would be more successful in these aspects partly because transport costs are typically a smaller proportion of their overall logistics operations. On the one hand, small firms sometimes have customers that are small firms too; hence they

are reluctant to pass on the costs of the charge to their customers. On the other hand, they have their own business to be concerned about and, therefore, cannot absorb the costs completely. The result is that firms may pass on a portion of the costs, such as in the retail sector, and consumers may experience an inflationary effect of road pricing.

- **Sector and type of product**

The sector that the firm is a part of, along with the type of product it deals in, determines much of its logistics strategy and operations. I found that certain sectors such as transportation may benefit from the road pricing policy, supporting an economic analysis by Verhoef et al. (1998). However, this may not be due only to increased efficiency from travel time savings as those authors predicted, but also due to the dependence of other firms on the transportation sector. As one respondent mentioned in the interviews – *“our influence is minimal; the transporters have more maneuvering space”*. The wholesale and retail sector and, in general, the distribution industry may have negative impacts of higher charges during peak hours because of regulated timings for picking up and delivering goods. The sector also determines aspects such as the position of the firm in its supply chain, for example, if it is a manufacturer that is higher up in the supply chain, a distributor, a retailer that is relatively lower in the supply chain, or the transport company on which these other firms depend. A higher position in the supply chain was expected to be advantageous. However, the interviews showed that the firm’s position in the supply chain did not matter as much as the balance of power in its relationships with other firms. For instance, a large retailer that gave a small manufacturer much business would have greater power in the relationship.

Within the different sectors, product characteristics such as whether or not the product is perishable, whether it is an intermediate or final product, the magnitude of transport costs as a share of total costs, and whether or not the product needs specialized equipment and vehicles are important in determining the transportation requirements of a firm. For example, if a product is an intermediate input into just-in-time operations of another firm or if it is a perishable product, the need for speed and reliability in transport is very high and shipments are more frequent. Owing to the nature of their product and their supply chain operations, firms thus have varying demands for reliability, flexibility, and other level of service requirements for their transportation. Additionally, these requirements determine the trade-offs that a firm will make in response to road pricing.

## - Location

Even though the majority of respondents mentioned that location changes were not likely to occur in response to a kilometer-based charge, we cannot rule out the impacts of road pricing on firm location. Some firms did mention that road pricing would threaten their competitiveness and they would be compelled to shift operations elsewhere or at least to take the policy into consideration when making future location decisions. In general, it was clear that location impacts depended on the design of the road pricing policy. In the case of kilometer-based charging as proposed in the Netherlands and as represented by Scenario 1 in our interviews, greater impacts are expected on the logistics operations of firms and on their production and distribution activities. In the Port of Rotterdam area, where our interviews were conducted, firms were bound to the location to a great extent because they depended on the port, its multimodal activities, and the allied businesses located near it. However, when the firms were presented with Scenario 4 that described urban cordon charges in addition to the kilometer charge, significant impacts were expected on location and accessibility. This was proved by the extreme concern shown by managers when responding to Scenario 4, and is understandable because the policy would add to already severe restrictions regarding the delivery of goods in the centers of cities. This was especially true for firms in the wholesale and retail sectors that had to make frequent trips into the urban centers to service customers or their own retail outlets.

### **5.2. Intervening variables -- Institutional factors**

Firms typically expected that road pricing would have net costs for them rather than net benefits. Table 11 shows their responses by size and sector regarding the incidence of costs from road pricing, i.e., who was expected to pay the increased costs in their business operations.

#### **TABLE 11 ABOUT HERE**

I found that the following institutional factors explained the expected incidence of costs arising from road pricing: (a) industry pricing norms, for example, who typically pays for road transportation in a firm's supply chain, (b) the level of competition that a firm faces in its market and the profit margins in its sector, (c) the relationships that a firm has with its suppliers, customers, and transport companies, and (d) other existing regulations that a firm faces. The incidence of the impacts of road pricing appeared to correlate with these institutional variables. A key finding was that whether or not a firm expects to pass on the costs of road pricing depended on the level of power it had in its relationships with customers or other firms. A firm's

ability to change its own operations or to demand changes in operations from other firms also depended on these relationships. The intervening institutional factors through which the impacts of firm size, sector, and location are expected to occur are discussed in this section. I explore the concepts of power-dependence relations among firms and the effects of their institutional environment, relating them to the findings from the interviews.

### 5.2.1. Findings Related to Power-Dependence Relations of the Firm in its Supply Chain

I found power-dependence relations, as discussed in Section 2.1, to be especially significant in the context of the transportation sector and its relationships with firms in other sectors. All transport firms in my study expected to pass on the costs of road pricing to their customers, the firms that shipped goods. The services provided by the transport firms were essential for all firms that did not perform their transport operations themselves. These firms had greater dependence on firms in the transportation sector, thereby giving transport firms the power to pass on all costs to them. For specialized transport and for high reliability requirements in case of just-in-time transport, there is greater dependence on transport firms, less power to influence operations, and less desire to switch to cheaper carriers because of uncertainty about the level of service. A respondent from a small flower wholesale firm mentioned that there were few options to change operations because of dependence on the transportation firms. In the words of the respondent: *“You are stuck to the transporter. The transport companies have their own ideas about logistics. You cannot change that easily. The only way to change that is to work with a different carrier. But actually they all work [in] the same [way].”*

In their study of the freight transport sector, Holguin-Veras et al. (2006) briefly mention the role of the balance of power between shippers and transport carriers. To explain the issue further, we return to the resource dependency theory discussed in Section 2.1 which states that the dependence of one actor on another is a function of the essentiality and substitutability of a resource. Cox et al. (2002) explain how the essentiality of a resource (product or service) for a firm is a composite measure of two factors, the operational importance of the resource for a firm, and the commercial importance of the resource to a firm’s overall revenue-generating activities (Cox et al. 2002). Operational importance refers to the indispensability (Caniels, Roeleveld, & Semeijn, 2002) of a particular resource to the firm’s operations, as are the transport services described above. As regards commercial importance, in all sectors, including transportation, firm size played a role in determining firm power, because it determined the amount of business provided by the large firm. Large size increased the power of a transportation firm and it increased the power of a shipper to pass on the higher transport costs



to its customers. The shipper also had more bargaining power if it was a large firm accounting for a high proportion of the transport firm's revenue.

With regard to substitutability, market competition is an important factor. Although competition for non-specialized transport services like container transport was high, large firms had the ability to meet customer demands more easily because they had a larger number of vehicles and drivers and larger networks of subcontractors. It was found that, in general, demand for reliable transport services is high while supply is relatively low due to a shortage of trained drivers in the Netherlands. This potentially increases the bargaining power of transport companies. Although firms in the transportation sector may benefit from higher productivity as a result of road pricing, most shippers did not expect that the projected reduction in congestion would actually occur. Therefore, they did not expect transportation companies to have any significant benefits from road pricing that would offset the increased costs. This further worked in favor of transportation firms, increasing the likelihood that they could pass on all costs of road pricing to customers.

#### 5.2.2. Findings Related to the Firm's Institutional Environment

The institutional environment within which a firm operates is determined by two key external factors—government policies or regulations, and market conditions. Existing regulations, including decisions about the type of road pricing policy to implement, shape the response of firms in certain sectors. This was proved by the level of concern shown in responses to Scenario 4 by firms in the wholesale and retail sectors. For the firms that must distribute goods into city centers, several constraints already exist, such as restrictions on times when goods can be loaded and unloaded, limitations on vehicle size, the requirement of special permits, and so on (Dablanc, 2007). The transportation sector is typically affected by macro scale policies regarding vehicle emissions standards, vehicle weight restrictions, and fuel prices, and also by policies at the urban scale, such as the restrictions described above for the goods distribution sector. There is also much competition in this sector from low-cost international service providers particularly from Eastern Europe. Mckinnon (2006) mentions how regulations governing drivers' hours and working time make it difficult for transport companies to avoid higher tolls at peak hours.

Market conditions that determine the level of competition and structure of inter-firm relationships also affect the institutional environment of firms. For example, the transportation sector had a common tradition of strong informal and formal networks between firms that had been working with each other for a long time. These networks existed not only among transport

firms but also in their relationships with firms in other sectors that were their customers. Transport firms often had no choice but to transfer the costs that they faced from increased regulations to their customers. This is because transportation is an essential service required by the shippers of goods and also because of a general perception of low profit margins in the transport sector. In the following section, I discuss testable propositions that can provide guidance in investigating the economic impacts of road pricing policies on firms.

## **6. Corroborating Institutional Factors from Literature: Advancing Propositions**

Organization theory analysts who focus on organizational adaptation emphasize the importance of two independent variables: (i) the choice that an organization and its managers have in decision-making, and (ii) the environmental determinism arising from sectoral characteristics that are out of the control of individual organizations. These two variables were considered mutually exclusive until Hrebeniak and Joyce (1985) proposed that both factors interact or coalesce to bring about organizational response (Hrebeniak and Joyce, 1989). High environmental determinism and high organizational choice can coexist and, in fact, organizations can be divided into four categories based on the manner in which the two dimensions of choice and determinism interact in the institutional environments in which they operate. These are shown in the quadrants in Table 12.

The previous section explains how the power and dependence relations among firms can determine whether they will be positively or negatively impacted by road pricing. Additionally, the institutional environment that a firm operates in determines what impact it might have from the policy. In studying how a firm might respond to road pricing, I found that the data from the interviews provided evidence of Hrebeniak and Joyce's theory. In this research, Hrebeniak and Joyce's (1989) use of the term "environmental determinism" can be understood as the constraints (or advantages) of regulations and market conditions in the firm's institutional environment. "Organizational choice", as described by the authors, is directly linked with the level of dependence of a firm on other firms and the power it has in these relationships. Recognizing that the data are limited in that they are obtained from only a small number of firms in a few sectors, I make some tentative propositions regarding the responses of firms to road pricing. I use the organizational-adaptation theory put forth by Hrebeniak and Joyce (1985), an empirical test of the theory by Lawless and Finch (1989), and the findings from the interviews as a basis for the propositions advanced in this section. The implications of each quadrant of Table 12 are also explained along with the propositions.

## TABLE 12 ABOUT HERE

### **1) Firms that belong in Quadrant I will face greater negative impacts of road pricing.**

These firms have relatively lower organizational choice and autonomy either due to their size, sector, or position in the supply chain. They have high environmental constraints due to existing regulations related to their sector or location. The interview responses show that these firms are most likely to be in the retail, wholesale, and consumer goods distribution sectors.

In Quadrant I, a firm has virtually no control over environmental forces (Lawless and Finch, 1989). It represents a situation of low power and high institutional constraints. This would include firms in highly competitive markets where market forces determine the prices that can be charged, many small firms, as well as large firms that sell unspecialized or undifferentiated products or services (Hrebeniak and Joyce, 1985). The firms in this environment face similar regulatory constraints and can be highly dependent on other firms or sectors. This resource dependency limits the level of choice that firms can exert in their behavior. The institutional environment has a high control over the firm such that it must either adapt or have difficulty surviving in a changing environment.

From our sample of firms, those from the retail and wholesale sectors, and those engaged in the distribution of goods are likely to face this environment. As described in Section 4.1.3, firms in these sectors operate in a context of high regulatory constraints and limitations on their operations, especially with regard to delivering goods into cities. They also had a high level of dependency on the transportation firms, in some cases because of specialized transport necessary for their product (such as flowers or fruit), or because of high reliability needs, leading to a lower level of choice in negotiating the costs of road pricing or making significant operational changes to their transport. The institutional constraints that these firms face could exacerbate the effects of road pricing on them. Respondents from these firms acknowledged that they would have to bear the partial or full costs of road pricing, not only because of constraints with regard to travel time and delivery schedules that were out of their control, but also because their customers would not accept the increased costs.

### **2) Firms that belong in Quadrant II would face lower negative impacts of road pricing.**

These are firms with typically higher organizational choice or power and also high institutional constraints in the form of regulations. Transportation firms, including smaller or non-specialized firms, are most likely to fall within this category.

In Quadrant II, both power and institutional constraints are high. Firms face certain external constraints that affect their decision-making; nonetheless they have some control and prerogatives despite the constraints imposed by the institutional environment (Hrebeniak and Joyce, 1985). Firms in industries that are highly regulated with regard to performance, product characteristics or the means of conducting business, are examples. Hrebeniak and Joyce explain that in spite of prevalent regulation, organizational choice is high in these sectors because of other factors such as size and market power, multiple means of achieving their outcomes, and low resource dependency on external sources (Hrebeniak and Joyce, 1985, p. 341). These organizations have the power to adapt within the constraints imposed on them (Lawless and Finch, 1989).

In my sample, the transportation firms seemed to fit this category best. This sector is constantly affected not only by market pressures that keep profit margins low but also from changing emissions standards, safety regulations, labor regulations, international competition, restricted delivery schedules imposed by the customer, and external factors such as fuels costs. Respondents from all five transport companies that were interviewed expected that they could pass on all the costs from road pricing to their customers. This was also an impact observed in Austria, Germany, and Switzerland, as discussed in McKinnon (2006). Profit margins in road transport are typically very low and there was no alternative to meet the costs but to pass the charges to the client. Customers also depend on transport companies to deliver their goods, especially in the case where specialized transport is required.

The constraints faced by firms in the transportation sector were frequently acknowledged by their customers, as revealed in the interviews. In addition, due to the resource dependency of other firms, transportation firms had greater latitude to pass on all the increased costs of road pricing to customers or change their operations as they deemed fit. These firms also had more power over customers to some extent because of the information asymmetry between them and their customers regarding transportation operations. The interview responses showed that all transportation firms, irrespective of size, had already been following methods to increase their operational efficiency, such as by working cooperatively with other transport companies, changing routes, consolidating loads, and avoiding peak hour transport to the extent possible, in response to congestion and rising costs. This implies that transportation firms can have substantially greater flexibility in their operations than their customers can have. Transportation firms with international operations were often already dealing with truck tolling schemes in Germany and were transferring all costs of road pricing to customers.

### **3) Firms that belong in Quadrant III would face negligible impacts of road pricing.**

These are firms with high power in their organizational relationships and less significant institutional constraints. This is because their dependence on transport carriers is lower, either due to non-essentiality of transport in terms of the share of transport costs in their overall operations, or because of the power to easily substitute the transport companies that they do business with. Large firms are most likely to fall in this category.

In Quadrant III, organizational choice is high and environmental determinism is relatively low, leading to a munificent environment that puts few institutional constraints on firms (Hrebaniak and Joyce, 1985; Lawless and Finch, 1989). The dependence of firms on scarce resources is relatively lower or less important to their overall operations. Firms can thus innovate and adapt proactively to external conditions in order to control their competitive position.

In my sample, manufacturing firms in the chemicals and food and beverage sectors, large firms, and those that offer specialized goods and services could be considered part of this category. These firms would not be much affected by the increase in transport costs as a result of road pricing because of one or more of these reasons—(i) they are large firms and the costs of road pricing would be relatively insignificant for them; (ii) they manufactured products in sectors where transport costs are a small part of overall logistics costs and other issues such as driver training, safety, and use of specialized equipment are more important; or (iii) they are specialized firms that provide a product or service with relatively inelastic demand and serve customers who would seek their business regardless of an increase in costs. Although these firms may be subject to some regulatory constraints in their environment, they have the power over other firms in their network due to their large scale of operations or level of specialization, to make operational changes as they wish, or to pass the costs on to customers, in response to road pricing. Even if they must pay a part or all of the costs of road pricing, they had the power to demand better services from transport suppliers. Quoting Hrebaniak and Joyce (1985) to distinguish between firms in Quadrant II and Quadrant III: “*The primary organizational task in Quadrant II is to maneuver around externally imposed prescriptions and proscriptions; in Quadrant III, the focus is more on goals and exercising discretion to optimize valued organizational outcomes.*” (Hrebaniak and Joyce, 1985, p. 345).

### **4) Impacts of road pricing on firms that belong in Quadrant IV would be uncertain.**

Quadrant IV included those firms that, on the one hand, faced an environment with few constraints, but, on the other hand, had limited power in their relationships. Due to inflexible

operations, they had very few strategic choices that they could make in response to a policy change such as road pricing. Such firms exhibit no coherent strategy and therefore, no particular pattern in strategies can be expected among them (Lawless and Finch, 1989). Their production and distribution network is less complex, with fewer or weaker linkages to other firms.

In my sample, the two firms from the construction industry (sand dealer and furniture manufacturer) appeared to fit this category. Respondents from both firms mentioned that they had no choice but to pass the costs on directly to the final consumers they dealt with because they could not alter their operations. They would pass on costs to customers even if they faced high competition because they had limited strategic choices. According to Hrebaniak and Joyce (1985), such forms would thus, “adapt by chance” to a policy change. If they were able to maintain their competitive advantage by raising their prices, they would adapt successfully, otherwise they would not. The impacts of road pricing would thus be uncertain for such firms.

A limitation of using Hrebaniak and Joyce’s framework of organizational adaptation in making these propositions is that some firms could belong in more than one quadrant depending on the relative importance of their size, sector, and location. The distinctions between the quadrants could blur depending upon these factors. For example, a large retailer located in the city center could belong in Quadrant I due to the level of institutional constraints that it faces. However, since it is a large firm, the positive impacts of higher power could outweigh the negative impacts of the institutional constraints. It could thus also fall in Quadrant III. Similarly, a large transportation firm could belong in Quadrant II, given the high dependence of other sectors on it, but it could also belong in Quadrant III if its large-scale operations resulted in offsetting the impacts of any regulatory constraints. In the following sections, I discuss some conclusions and policy implications of this study.

## **7. Conclusions and Policy Implications**

The key contribution of my study is that I help understand the impacts of road pricing policies on firms in heterogeneous economic sectors, taking into account the institutional environment in which firms operate. Using the relevant theories and stated responses obtained from the interviews, I presented a conceptual framework of factors governing the behavioral responses of firms to road pricing. These included the sector of the firm, its size, and its location as independent variables, and intervening variables related to the institutional environment. The interviews highlighted the importance of the institutional environment of firms in different

sectors, including the power-dependence relationships between them. I found these power-dependence relationships to be correlated with other variables such as firm size and sector. Firms in certain sectors such as transportation appeared to have more power since other firms depended on them. Smaller firms and firms in sectors such as wholesale and retail were more vulnerable to the economic impacts of road pricing due to lower market power and the effects of other constraining regulations. Firm responses to road pricing could involve changes that a firm makes to its transport operations; its overall logistics strategy in which transport might be one of many considerations; its decisions regarding location of premises, warehouses, and distribution centers; its efforts to avoid, reduce, or compensate for the increased costs in order to maintain its competitiveness; and its reliance on cooperation and partnerships with other firms to reduce the impact of the costs. Understanding these responses in context of the institutional environment of firms is crucial to ensure that a more comprehensive policy-making approach to implement road pricing is followed.

All interview respondents mentioned that their operations were affected by congestion and several respondents preferred that the revenues from road pricing be used to improve and expand the regional road network. The revenue-neutral design of the road-pricing policy proposed in the Netherlands has helped in pushing the policy forward politically by securing the support of a larger number of stakeholders. However, it is likely to have a relatively more benign effect in reducing congestion than other truck-tolling policies in Europe, because the revenues will be used to abolish existing vehicle taxes. This diminishes the incentives to change travel behavior, as was evident from some responses received in the interviews. The cordon charges, however, evoked much more concern from firms that routinely access the central city areas.

An important observation from the interviews was that businesses typically expected to face net costs from road pricing rather than net benefits. For example, firms neglect to consider the benefits they might receive from road pricing, such as lower taxes on new vehicles, the possibility of reduced freight rates, and the reduction in congestion due to the reduced number of cars on the roads. This was primarily because of the following reasons: (i) the expectation that congestion would not be reduced significantly by implementing road pricing, (ii) the uncertainty about passing on any increase in transport costs to customers, (iii) the inability to change operations and driving times because of customer requirements, and (iv) no benefits in the form of reduced freight rates despite the reduction in vehicle taxes for transport firms, because freight rates were based on other factors such as loading, distance, and labor hours.

If these perceptions are true, then questions arise about whether road pricing would indeed have higher economic costs than benefits and why decision-makers think that the policy would work. The problem faced by decision-makers is that most models and ex-ante analyses consider freight and the impacts on businesses in an aggregated way. As shown in this paper, the actual balance between the costs and benefits of road pricing for firms would vary significantly by economic sector, type of product, location, type of road pricing policy, power in organizational relationships, and the institutional environment. It is possible that some firms may face disadvantages due to road pricing. These must be identified and appropriate measures to mitigate negative impacts must be considered. The institutional factors led to a deeper understanding of the variables considered important at the start of the research, based on which the interview questionnaire was designed. For example, firm size was important because it actually correlated with resources and the power of a firm in its supply chain. The sector of the firm was crucial in understanding the institutional environment it operates in, the constraints or advantages it faces, and the level of independence it has in making strategic choices.

The institutional factors that I focused on in making the propositions were derived from Hrebaniak and Joyce's (1985) theory of organizational adaptation. Organizational choice relates to the power to make operational changes as desired, to pass on costs to customers as desired, or to make any trade-offs between operational changes, costs, and other logistical decisions. Environmental determinism refers to the influence of institutional conditions on a firm's operations, including regulations, market competition, and the type of road pricing policy. These conditions are not static. Policy changes such as the implementation of road pricing can alter the institutional environment that will affect future actions by firms. The actions of firms can alter the relative dependencies in their relationships. Environmental elements—competitors, regulators, and consumers—in turn, exercise their influence in similar attempts to retain or increase political or competitive advantage. With reference to Table 12, Hrebaniak and Joyce (1985, p. 347) explain that *“the net result of these interactions is that organizations may remain in Quadrant II, gain additional influence over their environment and move to Quadrant III, or lose power and move to the relatively disadvantageous conditions of Quadrant I”*.

The understanding of institutional factors is essential to ensure that road pricing policies can be made politically viable and that their effects can be best predicted ex ante. For example, all transport firms cannot be expected to move operations to off-peak hours under a road pricing policy that discourages peak-hour travel. This is because those firms that receive goods do not accept deliveries in off-peak hours, either due to choice or regulations. Therefore, road pricing



must be part of comprehensive policies aimed at reducing the costs of congestion to the economy, that take into account the labor hours, modes of operation, and other policies that affect various sectors. Transport movements cannot be significantly altered in isolation from these other conditions. This institutional perspective is important in considering the effects of road pricing not only on freight transport but also on commuters who use personal vehicles.

The case of transportation firms is particularly interesting because they form an important link between different actors in a supply chain. As mentioned above, transportation firms face constraints by customers that make it difficult to deliver goods in off-peak hours. Holguín-Veras et al. (2006) report from survey data that in only 9% of 1,271 trips that were analyzed in their study were transport carriers able to pass the charges from road pricing on to customers, suggesting that transport carriers did not have the market power to transfer costs. In contrast, my interviews show that carriers do expect to pass on the increased costs to customers. This suggests that there may be a difference in ex-ante perceptions of firms and the ex-post impacts—a topic on which not much research has been undertaken but that has important implications when considering business response to road pricing. If carriers indeed are able to transfer the costs of road pricing to customers as the respondents in our interviews expected, transportation firms may gain the most from the policy—a result supported by Verhoef et al. (1998) in a study done for the Randstad region of the Netherlands.

### ***Policy implications***

Studies on the impacts of road pricing on businesses and economic activity are scarce (Verhoef et al., 1998; Whitehead, 2002, 2005). Several studies have focused only on transportation firms (Hensher & Puckett, 2008; Holguin-Veras et al., 2006). In studies focusing on passenger impacts, research has been done on the impacts of road pricing on business-related passenger travel. However, impacts related to freight transportation remain underexplored.

This paper shows that it is important to take the impacts on businesses into account when planning the implementation of road pricing. Businesses often do not have complete knowledge about how the policy might affect them, given the lack of reliable data. Knowledge about these effects is even scarcer at the decision-making level where the focus tends to be on passenger impacts. However, businesses represent a powerful interest group that opposes road pricing. Therefore, it is important to investigate whether the economic impacts stated by them are likely to occur and why. Some firms may face relatively benign or no impacts from road pricing while others may be seriously disadvantaged. My research highlights some factors that could explain the differences in the types of impacts that firms could potentially face. An

understanding of these factors is crucial for building in measures into the policy design that could mitigate the negative impacts.

When forecasting the effects of road pricing, it is important for policy makers to take into account other policies affecting certain sectors and the dependencies that firms may have on freight transportation. Not taking these institutional factors into consideration could lead to unintended consequences of the policy. Although the level of power and organizational choice differs for all firms, policy makers can influence the institutional environment of firms by controlling the other regulations that govern firm response to road pricing.

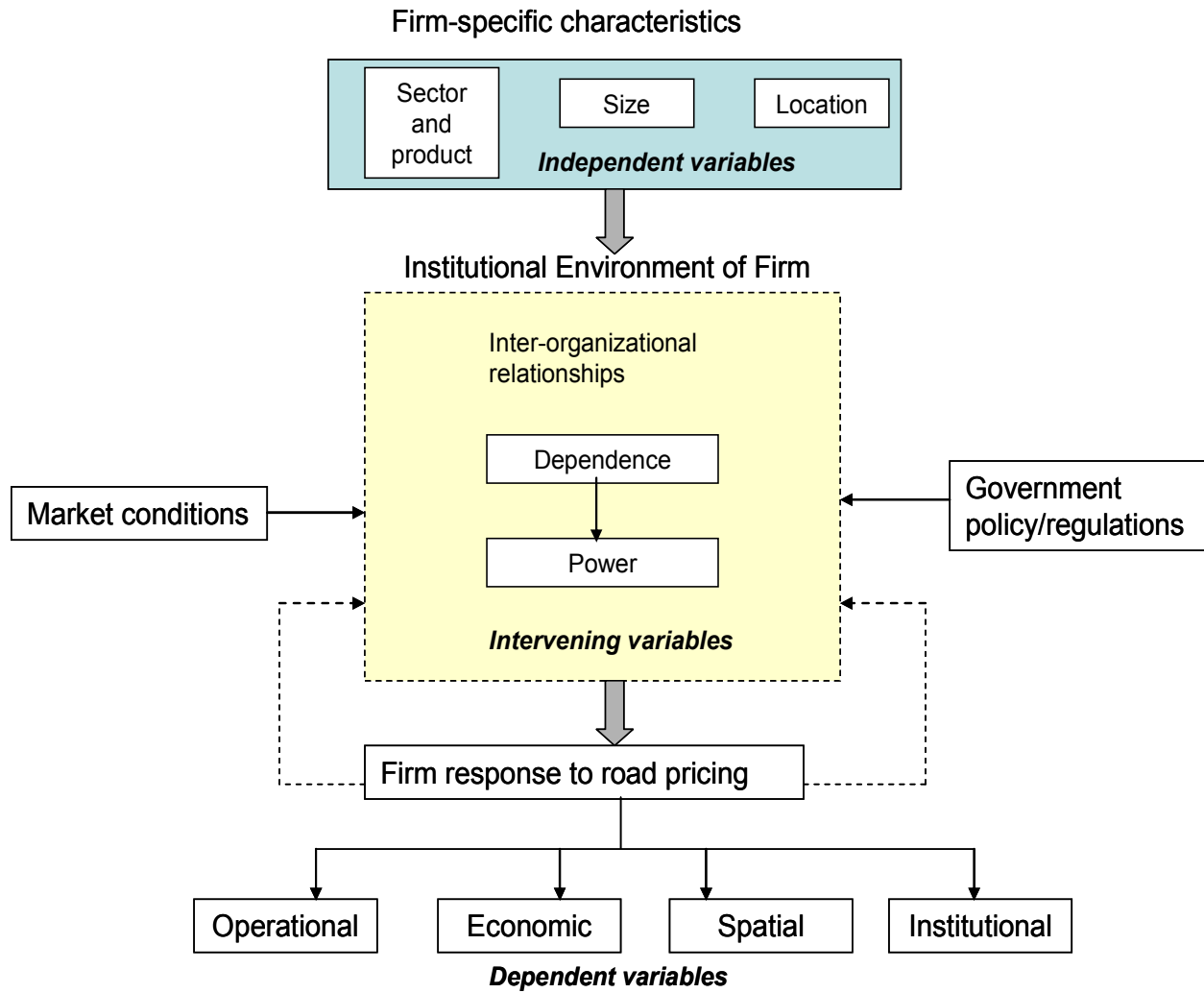
I followed a process of inductive analysis in order to arrive at a conceptual framework of factors affecting firm responses to road pricing. I used theories of organizational adaptation from organization theory literature to support my findings from the interviews and to advance propositions regarding potential impacts of road pricing on firms. In designing road pricing policies, I expect the conceptual framework and the propositions to provide guidance, primarily by indicating how firms in the different economic sectors may be impacted. I considered five key economic sectors of the Netherlands in this study; however, related propositions can potentially be made for all sectors and firms by carefully studying their institutional environment. With regard to implementing road pricing policies, this research could help policy-makers to:

- (i) predict which sectors and firms are likely to be vulnerable to road pricing and design mitigation measures—for example, provide incentives to firms that receive goods to accept deliveries in off-peak hours.
- (ii) consider road pricing in the entire context of other policies and regulations that a firm faces in its operations—for example, ensure that the time period when road pricing is in effect takes into account stipulations regarding freight loading and unloading times in urban areas and at the port, or provide a charge-free window during the day as an option for the delivery of goods.
- (iii) consider a comprehensive approach to planning a road pricing scheme so that all the links in a supply chain are taken into account—a conclusion supported by Hoguín-Veras et al. (2005).
- (iv) ensure the acceptance of firms prior to implementation, by taking their varied concerns into account;
- (v) ensure that the inflationary impacts and secondary economic impacts that may occur in certain sectors can be largely predicted and that consumers and businesses are aware of them.

At the end, it is important to emphasize some limitations of this study. The methodology of conducting a limited number of face-to-face interviews is useful for in-depth research, but it does not allow a generalization of the findings to all firms in the Netherlands. The analysis particularly suffers from the limitation of having only two respondents from very different types of firms in the construction sector. I found firms in the construction sector extremely difficult to contact for participation in the interviews. Future studies must be done to more reliably ascertain the impact of road pricing on this sector as well as the other sectors included in this research. Given the fact that road pricing has not yet been implemented in the Netherlands, the interview questions were all hypothetical. Therefore, some respondents could only provide an ambiguous assessment of the potential impacts of the policy on their firm. In reality, firms would determine their response to road pricing taking the responses of their competitors and partners into account. As this information was not available, the responses in my interviews may have provided incomplete information. Some respondents may also have answered the questions strategically depending on whether they supported or opposed the policy. Because my focus was on freight transport, I also did not discuss questions about impacts on firms related to business travel by employees in the interviews. Finally, since the interviews were conducted in an area that is in proximity to the Port of Rotterdam, the firms had other modal options that they could take advantage of, such as the possibility of shipping goods by rail or by barge on inland waterways. Most firms could not use these options because of the need for speed when sending small-sized shipments frequently. However, the location is unique because it offers firms alternatives that are not common in other locations.

In this study, I developed a conceptual framework and propositions to examine the potential responses of firms to road pricing taking institutional factors into account. Further research is essential to test these propositions and determine whether they hold across different contexts.

**Figure 1. Factors Affecting Firm Responses to Road Pricing –Conceptual Framework**



**Table 1. Sample of Firms Selected for Interviews by Size and Sector**

Sector	Firm size (number of employees)*				
	Micro (<10)	Small (<50)	Medium (<250)	Large (>250)	
Transport	1	1	0	3	5
Chemicals	0	0	4	1	5
Food and beverages	0	1	1	3	5
Wholesale and retail	1	1	0	2	4
Construction	0	1	1	0	2
<b>Total</b>	<b>2</b>	<b>4</b>	<b>6</b>	<b>9</b>	<b>21</b>

\*Firm size definitions are from the European Commission (2003)

**Table 2. Outline of Scenarios Discussed with Interview Respondents**

Policy variables	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	<i>Dutch Government Proposal</i>	<i>Environmental Scenario</i>	<i>Dedicated Lane Scenario</i>	<i>Urban Scenario</i>
<i>Expected Congestion Reduction</i>	30% reduction	50% reduction	Possibility of no congestion on dedicated lane of A15 Highway	30% reduction on highways and 30% within cities
<i>Average charge/km</i>	11 euro cents (US\$0.17)	50 euro cents (US\$0.76)	30 euro cents (US\$0.46)	11 euro cents on motorway AND 10 euro cents in city or cordon charge
<i>Coverage</i>	All roads in the Netherlands	All roads in the Netherlands	A15 highway	All highways and roads within four cities
<i>Use of revenues</i>	For reducing vehicle taxes and funding road infrastructure	For various public purposes, part of the general treasury	For the regional road network	For the road network and public transport
<i>Variation in charge</i>	By time of day and location	By vehicle emissions characteristics; Euro 5 vehicles exempted	By vehicle weight	By location and time of day
<i>Purpose</i>	To reduce congestion	To reduce emissions	To reduce congestion to and from Port of Rotterdam	To reduce congestion on national roads and within urban areas

**Table 3. Themes for Contextual Questions**

Category	Question themes
<i>Background</i>	Respondent's job and responsibilities Number of employees Number and locations of production sites and branches
<i>Product and Market Characteristics</i>	Type of product and how it is transported Market share and market characteristics Final product or intermediate product Turnover and production volume Product price and value density Level of customization -- made to order or made to stock Average order lead time and frequency of ordering Average level of inventory
<i>Supply Chain Characteristics</i>	Description of supply chain Position of firm in the supply chain Type of customer, e.g. distributor, retailer, or another manufacturer Number of customers and their locations Number of suppliers and their locations
<i>Transport Operations</i>	Own-account transport or use of freight carriers Important service requirements (e.g. low cost, speed, reliability) Type and length of contractual arrangements Who pays the transport costs of delivering to customers Who pays the transport costs of receiving goods from suppliers Average transport costs as percentage of value Transport modes used and in what proportion Frequency of shipments Demand for reliability and barriers to achieving it Time sensitivity due to perishable products or Just-In-Time operations Time periods in which goods are shipped Level of flexibility in conducting operations Daily ton-km or vehicle-km traveled Number and type of vehicles used

<i>Sectoral trends</i>	<p>Factors affecting organization and execution of transport</p> <p>Change in factors over past 3-5 years</p> <p>Adaptations or changes in operations over time</p> <p>Adaptations or changes expected in the future (up to 2020)</p> <p>Level and type of preparation to deal with anticipated changes</p>
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**Table 4. Themes for Questions on Effects of Road Pricing**

<b>Category</b>	<b>Question themes</b>
<i>Operations and logistics</i>	<p>Expected impact on transport in short, medium, and long term</p> <p>Expected changes in logistics strategy</p> <p>Aspects of road pricing scenario that will make changes necessary</p> <p>Changes currently under consideration or not</p>
<i>Location</i>	<p>Changes expected to location of current facilities and premises</p> <p>Changes expected for future facilities/premises</p> <p>Changes expected from suppliers or customers</p>
<i>Costs and competitiveness</i>	<p>Expected impacts on product prices and costs</p> <p>Expected impacts on profits</p>
<i>Organizational relationships</i>	<p>Level of control that the firm has over these impacts</p> <p>Barriers to making changes</p> <p>Extent of cooperation with customers, suppliers, and other firms</p> <p>Forms of cooperation expected</p>
<i>Acceptability</i>	<p>Will the policy help in reducing congestion?</p> <p>Is it acceptable or not?</p>

**Table 5. Responses to Road Pricing Obtained from the Interviews**

<b>Response Categories</b>	<b>Expected response or impact</b>
<i>Operations and Logistics</i>	Change travel routes
	Change travel times, avoid peak hours (e.g. deliver goods at night)
	Reduce number of trips or distance traveled
	Increase vehicle loading
	Increase efficiency of transport and logistics operations
	Change to cleaner vehicles
	Change opening times of premises to receive goods
	Change delivery schedules with customers

	Change travel mode
Location	Change location of outlets, warehouses or distribution centers
Decisions	Decentralize inventory to hubs near the customer, and outside NL
Costs and Competitiveness	No response possible—i.e. bear higher costs, with impacts on profits
	Transport companies pass on costs to shippers
	Shippers pass on all costs to customers through increased prices
	Share costs with transportation companies or other businesses
	Make profits due to increased efficiency
	No effect due to use of fixed prices or other reasons
Organizational Relationships	Subcontract or outsource transport operations
	Renegotiate contracts with customers or suppliers or both
	Negotiate with transport companies for better service
	Change customers
	Change suppliers or transport companies to lower costs
	Leave it to transport companies to manage—it is their concern
	Increase transparency in contracts with transport companies

**Table 6. Firm Responses related to Operations and Logistics**

Sectors applicable	Response strategy	Challenges mentioned by respondents	Possible Solutions
Chemicals, wholesale and retail	Increase vehicle loading	Loading is already at near maximum levels	Introduce longer vehicles to improve efficiency
Chemicals, food and beverages	Increase efficiency of transport and logistics	Operations are already optimized for maximum efficiency in the supply chain	Frequency of deliveries may be reduced by increasing loading
Chemicals, food and beverages, wholesale and retail, transportation, construction	Change travel times, avoid travel during peak hours (e.g. deliver goods at night)	<ul style="list-style-type: none"> <li>- Inflexible delivery schedules due to working hours in particular sectors constrain choice of travel time</li> <li>- Shops must be supplied before opening hours, therefore morning peak hour driving is necessary; customers cannot accept deliveries at night</li> <li>- Firms with own vehicles want to make maximum number of trips in a day for cost-effectiveness.</li> </ul>	Allow evening and night time deliveries and widen time windows for business at facilities such as the Port of Rotterdam
Chemicals	Change travel mode	- Customers can only accept small truckload-sized consignments either due to volume constraints or JIT	Increase mode share of rail and barge to the extent possible, but truck transport is most



		<p>operations.</p> <ul style="list-style-type: none"> <li>- In many cases, road transport is the only option available for time-sensitive products.</li> </ul>	attractive for shorter distances.
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**Table 7. Firm Responses related to Location Decisions**

<b>Sectors applicable</b>	<b>Response strategy</b>	<b>Challenges mentioned by respondents</b>	<b>Possible Solutions</b>
Chemicals, food and beverages, wholesale and retail, transportation, construction	Change locations of factories, outlets, warehouses or distribution centers	<ul style="list-style-type: none"> <li>- Location changes not possible due to high capital investments in current locations</li> <li>- Sources of supply (such as port for fruit wholesalers and flower auction for flower wholesaler) dictate current location, therefore location change not possible</li> <li>- Location of majority of customers determines current location in wholesale and retail, transportation, and construction sectors</li> </ul>	<ul style="list-style-type: none"> <li>- Implement road pricing all over Europe to maintain competitiveness of Dutch businesses</li> <li>- Consider road pricing in making future location decisions</li> <li>- Chemical firms suggested decentralizing inventory to hubs near the customer, and outside the country to allow greater flexibility in transport operations.</li> </ul>

**Table 8. Firm Responses related to Costs and Competitiveness**

<b>Sectors applicable</b>	<b>Response strategy</b>	<b>Challenges mentioned by respondents</b>	<b>Possible Solutions</b>
Chemicals, food and beverages	No response possible—i.e. shippers bear higher costs, with impacts on profits	<ul style="list-style-type: none"> <li>- Not possible to pass on increased costs to customers because they will not accept it.</li> <li>- Threatens competitiveness of Dutch businesses because the country is already very expensive to invest in</li> <li>- Millions of vehicle-km traveled in a year that would cause a significant increase in costs</li> <li>- Transport rates are based on distance driven and labor hours, which would remain the same</li> </ul>	
Chemicals, food and	Shippers pass on all or part of	<ul style="list-style-type: none"> <li>- Lack of acceptability by customers</li> <li>- Shippers depend on transport</li> </ul>	

beverages, wholesale and retail, construction	costs to customers through increased prices	companies and those that need specialized transport had less power to negotiate	
Wholesale and retail firms	Shippers share costs with transportation companies or other businesses	Transport companies already have low profit margins and congestion reduction was only speculative; therefore despite the reduction in vehicle taxes, shippers must pay the costs	Demand better level of service from transportation firms
Transportation	Make profits due to increased efficiency	Not likely that congestion would reduce enough to increase efficiency	Cooperate with other transport companies to increase efficiency
Transportation	Transport companies pass on all costs to customers	Profit margins are low in this sector therefore no other alternative is possible; negotiations will be required with shippers and customers	

**Table 9. Firm Responses related to Organizational Relationships**

<b>Sectors applicable</b>	<b>Response strategy</b>	<b>Challenges mentioned by respondents</b>	<b>Possible Solutions</b>
Wholesale and retail	Outsourcing of transport for better consolidation of goods, cost-effectiveness, and avoiding administrative and regulatory costs in different countries	<ul style="list-style-type: none"> <li>- For small firms this was a useful strategy but not necessarily for large firms because they had already found ways to optimize operations.</li> <li>- Outsourcing led to loss of transparency and control in transport operations.</li> </ul>	
Chemical firms	Cooperation with firms in same sector to make supply chain more efficient and reduce reliance on road transport	Larger firms tend to cooperate with each other while the smaller firms are left on their own	Cooperation among large firms to establish rail terminal at the port (ongoing)
Transportation	Negotiate terms with customers	High competition in the sector meant that larger companies could survive in spite of increased costs, but small companies would find it harder to negotiate with customers	

**Table 10. Interview Responses to Road Pricing Categorized by Firm Size, Sector and Type of Response**

Categories of Responses	Chemicals firms				Food and Beverages firms				Wholesale and Retail firms						Transportation firms			Construction firms		No. of firms that would respond this way	No. of firms that would NOT respond this way	
	Small-med.		Medium		Large		Small		Micro		Small-med.		Large		Micro		Small		Small-med.			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			20
<b>Operations &amp; Logistics</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Change travel routes	✓			✓					✓													
Change travel times: avoid peak hours (e.g. deliver at night)																						
Reduce number of trips or distance traveled																						
Increase vehicle loading																						
Increase efficiency of transport and logistics operations	✓	✓	✓	✓																		
Change to cleaner vehicles*																						
Change opening times of premises to receive goods																						
Ability to change delivery times/schedules																						
Change travel mode	✓																					
<b>Location decisions</b>																						
Change location of warehouses or distribution centers																						
Decentralize inventory to hubs near the customer																						
<b>Costs &amp; Competitiveness</b>																						
Will have to bear higher costs with impact on profits	✓	✓	✓	✓																		
Transport companies will pass on costs to us that must be paid	✓	✓	✓	✓																		
No reduction in congestion expected																						
Ability to pass on some costs to customers by raising rates	X	X	X	✓																		
Share costs with transport firms	✓	✓	✓	✓																		
No effect due to fixed prices or other reasons																						
Possibility of making profits due to increased reliability																						
<b>Organizational relationships</b>																						
Subcontract or outsource transport operations																						
Renegotiate contracts with customers, suppliers or both																						
Ability to negotiate with transport companies for better service	✓	✓	✓	✓																		
Change customers																						
Change suppliers or transport companies to lower costs																						
Leave it to transport companies--it is their problem																						
Increase transparency in transportation contracts																						

Note: Since the responses were open-ended, blank cells imply that the respondent did not mention that particular response

\* This response is specifically for Scenario 2 (Environmental scenario)

\*\* Several firms gave more than one response in each category

\*\*\* Firm size definitions used in this table are: Micro = Less than 10 employees; Small = 11-50 employees; Medium = 51-100 employees; Large = More than 250 employees

**Table 11. Responses Showing Incidence of Road Pricing Costs**

<b>Sector</b>	<b>No. of firms</b>	<b>Summary of Responses Showing Expected Incidence of Road Pricing Costs*</b>
<b><u>Transport</u></b>		
Micro	1	We will pass the costs on. The client depends on us; therefore they have to accept the charge or else we won't deliver.
Small	1	We can pass costs to customers given good media communication; we pass costs of the German MAUT to customers.
Large	3	Customer will pay 100%. Shippers always pay the transport costs. Confident that customers will pay even if they resist at first; they depend on us for specialized transport which is in short supply.
		The charge is not a problem for us because we will pass it on to customers, but we don't believe congestion will reduce.
<b><u>Manufacturing (chemicals, food and beverages)</u></b>		
Small-medium	3	If transporters face higher costs, the costs will be passed on to us. We cannot pass on full costs to our customers.
		Transport companies will pass on costs to us and we have to accept them but we will ask for a better level of service.
		Transport companies will pass charges to us and we will try and pass them to customers. This threatens our competitiveness.
Medium	1	Transport companies would charge us and we have to pass it on to customers.
Large	3	Costs will have no effect because they are very small in absolute terms and we can pass 100% to customers.
		We expect an average impact for the distance-based charge. The costs will be a small amount but even that impacts profits.
		We do not expect any congestion reduction. We will pay the costs; it will only be one of many components of our logistics costs.
<b><u>Wholesale and retail</u></b>		
Micro	1	We have to pay. Transport companies will pass the costs to us but we cannot pass on full costs to customers.
Small	2	It is the transport company's problem because we pay fixed prices to our exporters who may be in Brazil.
		Transport companies will pass on costs to us. It is impossible for us to pass on all costs to customers
Small-medium	1	I don't know how it will impact us. The transport company will know about that.
Large	3	We just have to bear the cost and can do nothing about it. We cannot change delivery times because of customer schedules.
		Transporters have low profit margins and will pass on the costs to us. We will pass on at least half of the charge to customers.
		Margins for transporters are very tight, so we will have to pay the

costs. We expect a reduction in profits of about €200,000 a year.

**Construction**

Small	1	We cannot change transport operations, so we have no choice but to pass on full costs to the customer.
Small-medium	1	We have no choice but to pay and increase prices for customers. Off-peak driving is not possible in sectors such as construction.

**Total 21**

\* Note: These responses are primarily for Scenario 1, based on the kilometer charge currently proposed in the Netherlands.

**Table 12. Framework for Organizational Adaptation with Examples of Firm Types**

<b>Firm power</b> ("Organizational choice" in Hrebeniak and Joyce's theory)	<i>High</i>	<b>III</b> Manufacturing firms (in food and beverages and chemicals sectors) Specialized firms	<b>II</b> Transportation firms
	<i>Low</i>	<b>IV</b> Construction firms	<b>I</b> Wholesale and retail firms
		<i>Low</i>	<i>High</i>
<b>Institutional constraints</b> ("Environmental determinism" in Hrebeniak and Joyce's theory)			

Source: Hrebeniak and Joyce, (1989)

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## **PAPER 3**

### **Implications of the London Congestion Charge for Firms in Key Economic Sectors: Influencing Factors, Impacts, and Responses**

# Implications of the London Congestion Charge for Firms in Key Economic Sectors: Influencing Factors, Impacts, and Responses

## 1. Introduction

The London Congestion Charging scheme is widely considered a successful<sup>21</sup> example of how a scarce resource, in this case road space, can be managed through the price mechanism. Congestion charging<sup>22</sup> was first implemented in London on February 17, 2003 with a daily charge of £5 (US\$10)<sup>23</sup> for private vehicles entering a 21 km<sup>2</sup> zone in central London between 7 AM and 6:30 PM on weekdays. Certain vehicles are exempted such as those belonging to emergency services and disabled persons, two-wheelers, very low-emission vehicles, and taxis. Residents of the congestion charging zone receive a 90% discount on the charge.

The policy has resulted in reducing traffic inside the zone. The number of vehicles entering the zone is reported to have decreased by about 16% on average (TfL, 2007). Average speeds increased from about 14 km/hr in 2002 before charging was introduced to about 17 km/hr in 2004, then progressively fell back to 16 km/hr in 2005, and 15 km/hr in 2006—the last figure being attributed to significant road works in 2006 (TfL, 2007). Two years after it was first introduced, the charge was increased to £8 (US\$16) to reduce congestion further (GLA, 2005). After another two years, on 19 February, 2007, the area of the congestion charging zone was almost doubled to include a western extension. Figure 1 shows the combined central and western congestion charging zone that encloses the core shopping, government, entertainment, and business districts of the Greater London Area. According to Transport for London's estimates, the number of car trips into the original congestion charging zone has fallen by 15,000-20,000 per day, of which 20–25% are displaced through trips, 60–70% have shifted to public transport and other modes such as two-wheelers, bicycles, and taxis, and about 15% have been diverted to other times or to alternative destinations (TfL, 2005). The revenues from

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<sup>21</sup> A study by (Prud'homme & Bocarejo, 2005) is one of the few which attempts to show that the London Congestion Charge is an economic failure, even though it is considered a political and technical success. Through a benefit/cost analysis, the authors show that the high cost of operating the scheme and collecting the charges relative to the original cost of congestion, is the chief reason for drawing this conclusion.

<sup>22</sup> I use the terms "congestion charging" and "congestion pricing" interchangeably. In the form that the policy has been implemented in London, I consider it a sub-category of policies represented by the broader term "road pricing".

<sup>23</sup> Currency conversions were done on July 1, 2008 using the Universal Currency Converter from the website <http://www.xe.com/ucc/>.

the congestion charge are mandated to be used for public transport improvements for a period of ten years (Banister, 2003).

## FIGURE 1 ABOUT HERE

Economic assessments of the London congestion charge (CC), specifically its impacts on businesses, are controversial (Quddus, Bell, Schmöcker, & Fonzone, 2007; Schmöcker, Fonzone, Quddus, & Bell, 2006; Vickerman, 2005). As a result of congestion charging, businesses may experience supply side effects and demand side effects. Positive supply side effects relate to higher productivity and cost savings due to reduced delays and more reliable journeys. Negative supply side effects relate to an increase in compliance costs and charges passed on to businesses from suppliers and freight transport operators (TfL, 2007). Demand side effects on businesses primarily relate to the avoidance of the charge by consumers and a diversion of consumer expenditures away from the charging zone. The combined effects may be positive for firms in certain sectors and negative for others. When urban congestion charges are implemented, Whitehead (2005) describes how economic interactions work upward and downward between road users who are affected by the charges; businesses whose customers, employees, and deliveries are affected; property developers and owners who provide floor space; and the charging authorities responsible for spending the revenues on improvements. In this paper, I systematically analyze some of these interactions, focusing on the differences in the effects of the congestion charge among different types of firms.

Through a survey of firm managers, this paper presents an empirical analysis of the impacts of congestion charging on firms in London five years after the policy was first implemented. I study impacts related to changes in the accessibility, operations, and profitability of firms across the key economic sectors of the city. A conceptual framework that I developed in prior research (Mahendra, 2008a)<sup>24</sup> has been adapted and applied to conduct this ex-post analysis. At a time when a draft bill for a national road pricing scheme is under consideration in the British parliament, a better understanding of the impacts of the current congestion pricing policy on economic activity is imperative.

One of the key reasons congestion charging has been difficult to implement wherever proposed, is resistance from two important stakeholder groups—car drivers and businesses. In this paper, I focus attention on the latter group because car drivers are more flexible in their choice of

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<sup>24</sup> Paper Number 2 that is part of this dissertation

transport modes and routes than businesses. Unlike the impacts on car commuters, the impacts of congestion pricing on businesses across several economic sectors are not well documented in the literature. It is essential to consider any negative impacts on businesses in order to build in mitigation measures and ensure acceptance of the policy. The London CC has brought increased worldwide attention to the policy (Jowitt, 2004) and following its implementation, urban congestion pricing has been proposed in two large urban areas—New York City in the US and Manchester in the UK. Other cities such as Stockholm and Milan have recently implemented the policy. In the UK itself, urban congestion pricing is under consideration in other cities such as Leeds, Bristol, and Manchester. As part of the national Climate Change Program, the UK government has established a Transport Innovation Fund to support the implementation of congestion pricing by local authorities through a package of transport measures, providing investments up to the year 2015 (DEFRA, 2006). The lack of support of businesses is currently a detriment to advancing initial proposals for congestion pricing in Manchester, and concern by retailers was a reason the city of Edinburgh did not implement the policy after a public referendum (Schmöcker et al., 2006). The absence of empirical evidence in this area is thus an important problem to overcome.

Transport for London (henceforth, TfL), the local transport agency that implemented the CC, has been monitoring and documenting the business and economic impacts of the policy on an annual basis (TfL, 2003; 2004; 2005; 2006; 2007). However, aggregate statistics that have been used in the TfL reports are not sufficient to understand the adaptation processes and behavioral responses of firms. Aside from the TfL reports, studies on congestion pricing that take a variety of sectors, sizes, and types of businesses into account are scarce. Therefore, considering that business is clearly one of the stakeholders most affected by this policy, an important research priority is to conduct more representative surveys of business attitudes, which compare organizational effects by economic sector, size and location (Lyons, Dudley, Slater, & Parkhurst, 2004). There is some evidence that the services sectors have received benefits from congestion charging while the retail and restaurant sectors have been disadvantaged (TfL, 2006). Then essential questions arise regarding the changes that firms have made or are making to overcome the increased costs. What are the characteristics of the sectors and the firms within them that prevent realization of the benefits of travel time savings and productivity gains? What are the additional burdens they face from the implementation of congestion charging in London? The adaptation process of small and medium enterprises in

these sectors is especially important to study because the charge is likely to represent a relatively high proportion of their operating costs.

### **1.1. Research Objectives**

This research focuses on the London Congestion Charging scheme for two reasons. First, the London policy is a recent case of implementation in a large metropolitan region with the explicit objective of congestion reduction. Second, it offers the opportunity to understand the ex-post responses of firms after five years and how, if at all, business attitudes towards the policy may have shifted over time.

In this paper, I present results from a survey of firms across economic sectors in London to understand how they are impacted by the congestion charge, the factors responsible for these impacts, and the measures firms have taken to respond to the impacts. The economic sectors I studied include all categories of services, wholesale and retail, restaurants, freight transportation, construction, and the important low technology manufacturing sectors, such as printing and publishing and food manufacturing that are concentrated in the city. My aim is to answer the following research question.

What *factors* govern the impacts of urban congestion charging on firms in London, what *types of impacts* are firms in different sectors facing, and *how do firms respond* to the effects of the policy?

The sub-questions that will help answer this broader question are:

- Which types of firms are likely to face negative impacts of urban congestion pricing in London and which types of firms are likely to face positive impacts, and why?
- What factors are likely to cause differential impacts of congestion charging between firms?
- What is the relationship between a firm's institutional environment and the impacts it experiences from congestion charging?
- What are some specific advantages and disadvantages that businesses across economic sectors have experienced as a result of congestion charging in London?
- What have been the behavioral responses of firms to congestion charging in London?

## **1.2. Literature Review**

Surveys of business attitudes and the responses of firms to congestion pricing represent a distinct minority compared with those for public attitudes as a whole (Lyons et al., 2004). Several studies have been done on the public acceptability of pricing policies (Jones, 1998; Schade & Schlag, 2003; Viegas, 2001; Wachs, 1995b), with most of the research focusing on the attitudes of commuters to the policy.

Since the introduction of the London CC in 2003, studies of business impacts have been conducted by organizations such as Transport for London (TfL), the Commission for Integrated Transport (CfIT, 2003), the London Chambers of Commerce and Industry (LCCI, 2004, 2005b), the Freight Transport Association (FTA, 2004), and independently by Quddus et al. (2007) and Schmöcker et al. (2006). Of these, only the first two focus on multiple sectors. The LCCI studies focus only on the retail and restaurant sectors, the FTA study only on freight operators, and the studies by Quddus et al. (2007) and Schmöcker et al. (2006) on a single store in the retail sector. The conclusions of the most recent of these studies are shown in Table 1.

### **TABLE 1 ABOUT HERE**

Several of these studies report a substantial negative impact on the retail sector and the restaurant sector (CfIT, 2003; LCCI, 2004, 2005b; RICS, 2005). Only the annual monitoring studies by TfL include the complete range of sectors considered in this study and can be useful to compare results. Although these studies cannot be generalized, they raise doubts about TfL's conclusion that there is no independently observable impact of the CC on businesses in London (TfL, 2006, 2007), an argument used to justify extending the charging zone in 2007, and raising the congestion charge.

Given that the above mentioned surveys are primarily conducted by agencies with an interest on one side or another in the debate regarding the economic impacts of congestion charging, the London Chamber of Commerce and Industry has called for an independent and objective assessment of the impacts of congestion charging on businesses in and around the CC zone (LCCI, 2005a). Most of these surveys were conducted in the years soon after the CC was introduced and they report the resultant impacts on firms without exploring the reasons for the impacts.

An early study conducted in 2003 for the UK Commission for Integrated Transport noted that differences in business attitudes to the congestion charge varied by the extent to which firms were able to capitalize on the indirect benefits of the charge (CfIT, 2003). It was found that smaller businesses were less able to take advantage of the reduction in congestion. Further, the study found that owing to the lower bargaining power of a small firm in its business relationships, suppliers and distribution businesses typically imposed surcharges for deliveries made inside the congestion charging zone or reduced the frequency of deliveries, without taking improvements in efficiency into account (CfIT, 2003). Smaller firms are unable to dictate the times when goods will be delivered, often as a result of existing regulations regarding delivery times. They are also less able to challenge the increased costs of surcharges or to pass them on to customers. Transportation and delivery costs also make up a larger proportion of the total costs for smaller businesses than for large businesses. The study, done soon after the implementation of the congestion charge, mentioned that this was a short term trend and the market would correct itself in the medium term. I was looking for evidence of this in my research. By designing an appropriate sample of London businesses and statistically quantifying the effect of firm size, sector, location, operational factors, and institutional factors on how small and medium-sized firms have been affected by the congestion charge, I contribute to a more detailed understanding of the economic impacts of the policy on different types of businesses.

### ***1.3. Critique of the impacts monitoring methodology used by TfL***

To evaluate the business and economic impacts of congestion charging, Transport for London uses data from several databases to compare business performance inside the zone with business performance outside the zone, both before and after introduction of the policy. Business performance is measured by variables such as annual change in the number of businesses, employees, sales, and profits, in aggregate for firms in different sectors. TfL's conclusion, drawn from the successive years of monitoring impacts is that "in net terms, business has not been affected positively or negatively by congestion charging" (TfL, 2006) and that the impact has been broadly neutral. This is a conclusion accepted by some experts in their research on economic impacts of the London CC policy (Santos & Fraser, 2006). However, the most recent report mentions that "this does not preclude the possibility that certain businesses in specific sectors may have been differentially impacted" (TfL, 2007, p. 77).

TfL follows this methodology because it assumes that there must exist “notable shifts in relative trends” inside and outside the zone (TfL, 2006; p.73) in order to conclude that there has been a likely impact of congestion charging on business activity. The agency argues that adverse impacts in some sectors cannot be attributed to congestion charging alone because other economic effects, such as the start of the war in Iraq and the temporary closure of the Central Line (a key transit line that serves the central London congestion charging zone) in 2003, a general economic slowdown in 2003, terrorist bombings in the city in 2005, and an interest rate increase in 2006 could also be responsible. But the study by Quddus et al. (2007) uses detailed sales data from a single large retail store—the John Lewis store—for an econometric analysis that isolates the impacts of all these factors including congestion charging. The study concludes that the congestion charge is independently responsible for a decline in sales of 5.5% or 8.2% depending on the model used, at the branch of the store located inside the congestion charging zone. This study therefore, measures mainly the demand side effects of congestion charging on the retail sector, showing that consumers have reduced their shopping trips—a result also corroborated in a related study by Schmöcker et al. (2006).

TfL’s analysis seeks to identify changes in longer-term trends that have occurred specifically within the congestion charging zone and not elsewhere. This rigidity in the evaluation of impacts ignores the dynamic nature of business activity that is not concentrated only inside the congestion charging zone, but occurs *between* firms located inside and outside the zone. To summarize, the impacts-evaluation methodology used by TfL suffers from three problems:

- (1) The use of aggregate statistics to measure change in number of businesses, turnover, sales, employment, and profits. Aggregate statistics, while indicating broad trends, obscure the sector-level and firm-level impacts and are typically skewed by data from the largest firms.
- (2) Comparison of firms located inside the CC zone with a control group of firms located outside the zone. This is the key flaw in the methodology because the types of firms that are located inside and outside the zone are different (TfL, 2006). Firms in the manufacturing, wholesale, construction and some services sectors are much more concentrated outside the central London CC zone. Whereas, firms in the finance and business services sectors are concentrated much more inside the CC zone (TfL, 2006). Most firms located outside the zone, such as in the wholesale, manufacturing and construction sectors, do business inside the zone and vice versa. Therefore, it is not simply the impacts on businesses inside the zone that are important. The problem here is the use of firm location as a control variable.



(3) For the retail and restaurant sectors, TfL uses the indicator “retail traffic or footfall” and this is useful; however referring back to the demand and supply side effects mentioned earlier, the change in sales or number of customers is only one of several factors that may drive the effects of congestion charging on firms.

## **2. Research Design and Methods**

Based on the conceptual framework developed in Mahendra (2008) and on studies completed by the LCCI and TfL, I developed a questionnaire to survey a sample of about 400 firms. As a first step, I selected sectors important to the city’s economy and those that rely heavily on transportation. Firms in these sectors as well as firms located within and outside the congestion charging zone<sup>25</sup> were selected to form a sample. Managers, specifically senior managers or those knowledgeable about the firm’s transport operations, were interviewed with structured questions about the impacts of the London Congestion Charging scheme and their firm’s responses. Transport for London also conducted a survey of over 1,200 businesses in the Greater London Area and reported results in its Fourth Annual Impacts Monitoring Report (TfL, 2006). Although the TfL study was useful for cross-comparison, it does not answer the particular questions that this research proposes—namely the impacts of the congestion charge and the adaptation of business operations by firms along various dimensions apart from costs.

### **2.1. Survey Objective and Mode**

Survey research has been commonly used to study attitudes toward transportation policies and expected or revealed impacts among businesses (Golob & Regan, 2000; Holguin-Veras et al., 2006; A. C. McKinnon, 1999; Quddus et al., 2007; Regan & Golob, 1999; Runhaar, 2002; Schijndel & Dinwoodie, 2000). The objective of this survey is to investigate the importance of various firm characteristics, institutional factors, and operational factors in determining the impacts of congestion charging on small and medium-sized firms in London, and the resulting behavioral response of firms.

For this research, a telephone survey was the preferred methodology<sup>26</sup> for several reasons. First, telephone surveys offer a high degree of quality control over the entire data collection

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<sup>25</sup> All references to the “congestion charging zone” in this study include the original central London congestion charging zone and the Western extension combined.

<sup>26</sup> Approval from the MIT Institutional Review Board, the Committee on the Use of Humans as Experimental Subjects (COUHES), was obtained prior to conducting the survey.

process, including sampling and respondent selection based on answers to certain screening questions. Questions can also be asked with the use of probes where needed (Lavrakas, 1993). This is considered the most important advantage of telephone surveying. Second, telephone surveying is a more cost-effective data collection process in terms of achieving the desired sample, with costs much lower than face to face interviewing and typically higher response rates than mail surveys (Czaja & Blair, 2005). The third advantage of telephone surveys is the much shorter period of data collection as compared to mail surveys or face-to-face interviews. The sample of respondents can also have a wide geographic distribution. Finally, a key advantage of telephone surveys for an emotive topic, such as congestion pricing, is that controversial subject matter can be discussed more easily than in face-to-face interviews because the respondent cannot see the reactions of the investigator (Blankenship, 1977). The disadvantages of telephone interviewing are the constraints on the length of the interview, the limited complexity of the questions asked, constraints on the number of answer choices provided, and the inability to use visual aids (Czaja & Blair, 2005; Lavrakas, 1993).

## ***2.2. Firm Selection and Sampling***

When the intent of a survey is to study interrelationships among variables rather than the extent to which a variable is present in the larger population, pure random sampling is less important and the sample should be chosen more deliberately or purposively (Lavrakas, 1993; Punch, 2003). Through this survey, my objective was not to measure the proportion of all London businesses that have been positively or negatively impacted by the congestion charge but to understand what types of firms were more or less positively or negatively impacted and why. According to Fowler (2002), for such a purpose, a sampling design that ensures a heterogeneous sample but not necessarily a random one can be sufficient. It is recommended that the sample be selected so that any relationship between the variables has the maximum chance to be observed (Punch, 2003). Therefore, in order to test the effect of sector as an explanatory variable, I selected six key sectors in the London economy, to test the effect of location, I included firms located inside and outside the CC zone in the sample, and to test the effect of firm size, I included micro, small, and medium-sized firms, measured by the number of employees. The categorization of firm size was based on the number of employees working at the location of the surveyed firm.

### 2.2.1. Stratification by sector

The sectors included in this study were selected based on three criteria:

- (i) their contribution to the regional economy of London in terms of Gross Value Added, (ii) importance in the economy in terms of level of employment, and
- (iii) their reliance on transportation for business, supply or delivery of goods.

The sectors, specified by SIC code (listed in Section 1 of the Appendix) include:

(a) Wholesale and retail; (b) Construction; (c) Freight transport and supporting services—this subset of the overall transportation sector was selected for its particular relevance to the research questions; (d) Restaurants, including bars, and canteens; (e) Financial, insurance, and business services; and (f) Low technology manufacturing—including firms dealing in printing, publishing and production of recorded media, food products and beverages manufacturing, furniture manufacturing, and apparel.

These sectors broadly account for about 84% of the Gross Value Added in the Greater London economy (ONS, 2007), about 95% of all private sector enterprises in London and about 95% of total employment in London (Prothero, 2008)<sup>27</sup>.

In 2003, about 75% of the goods vehicles entering and leaving central London daily were light vehicles or vans, 20% were medium vehicles, and 6% were heavy goods vehicles<sup>28</sup>. A large proportion of van trips are made to carry out freight and servicing work within London. The six selected sectors broadly account for about 75% of the total van trips within London and about 80% of the total vehicle-kilometers<sup>29</sup>. Construction is the most important business type both in terms of trips and vehicle kilometers, followed by wholesale and retail trade, and the hotels and restaurants sector (Browne et al., 2004).

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<sup>27</sup> These figures included the category of Hotels and Restaurants, rather than only restaurants and included all manufacturing sectors in a single category.

<sup>28</sup> Light goods vehicles are those with a gross weight of up to 3.5 tons, medium goods vehicles are 2-axle rigid vehicles with a gross weight above 3.5 tons, and heavy goods vehicles are all other goods vehicles over 3.5 tons with 3 or more axles (Browne, Allen, & Christodoulou, 2004).

<sup>29</sup> The Department for Transport (DfT, 2004) statistics mentioned in the report by Browne et al. (2004) only provide a broad distribution of trips and vehicle-kilometers with no detailed breakup by industry code. 2004 was the first year that the DfT surveyed company-registered vans and privately-registered vans as part of its Continuing Survey of Road Goods Transport. The data include categories for “other manufacturing industries” and “other services”. I did not include all manufacturing sectors, but only the low-technology manufacturing (not accounted for separately in the DfT statistics) sector in my survey and I included a variety of professional services sectors such as the firms of architects, designers, lawyers, and other sectors not represented by financial and business services. Therefore, I halved the reported numbers for these categories to get a conservative estimate for the services and manufacturing sectors included in my survey.

### 2.2.2. Stratification by firm size

The firms included in the survey are Small and Medium Enterprises (SMEs), defined as having less than 250 employees. These were stratified as follows, based on the number of employees and according to the UK Office of National Statistics definitions –

Micro: 1-9 employees, small: 10-49 employees, medium: 50-250 employees

The reason for focusing the survey on SMEs was to cover the category of firms most likely to be affected by congestion charging so that the relationships among the impact factors could be adequately assessed. About a third of all firms<sup>30</sup> in the United Kingdom are located in London. Regional statistics show that at least 99% of firms are small (0 to 49 employees), 0.5-0.8% are medium-sized (50 to 249 employees), and no more than 0.2% of enterprises are large (250 or more employees) in all regions of the country, including London (ONS, 2006). The six sectors I focus on in this study comprise 96% of all SMEs in London, representing 46% of London's total private sector employment (Prothero, 2008). In the central London CC zone, 82% of businesses have 10 employees or less (TfL, 2003). This highlights the importance of studying SMEs as it is by far, the predominant category of firms in London.

In addition, small and medium firms are concentrated in the sectors relying most heavily on road transport, i.e. construction, wholesale, and manufacturing (Prothero, 2008). Large firms are most concentrated in the retail, financial services, and transportation sectors. An advantage of studying smaller firms in this research is that they usually function as part of one primary sector unlike large firms that cannot typically be assigned to one sector because they often produce multiple products.

### 2.2.3. Stratification by location

The sample, purchased from a private sampling company, included SMEs in the sectors specified above. Location of the firms was specified by the postcode. Firms were sampled in postcodes that are part of the original central London congestion charging zone, the western extension of the zone, and postcodes outside the combined congestion charging zone.

### 2.2.4. Sampling

The survey was conducted using a stratified random sample with disproportionate stratification by sector such that the proportion of firms in each sector of the sample did not reflect the

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<sup>30</sup> These ONS statistics relate solely to the private sector, comprising companies (including public corporations and nationalized bodies), partnerships, and sole proprietors.

proportion of firms in those sectors in the actual population (Singleton & Straits, 1999). Disproportionate stratification was used to ensure that there were sufficient responses for each sector to facilitate statistical analysis of differences between sectors. For example, only about 3% of small and medium-sized firms in London are in the transportation sector (Prothero, 2008). To include a minimum number of firms for statistical analysis, the proportion of transportation firms in the survey sample is 5%, including firms located inside and outside the CC zone. In the overall sample, about 24% of firms were located outside the zone and 76% were located inside the combined central and western congestion charging zone. Figure 2 shows the distribution of firms in the sample by sector and location. The sample comprised a larger number of firms in the wholesale and retail, services, and restaurant sectors as such firms are predominant in the London economy, particularly inside the congestion charging zone. Construction, manufacturing, and transportation firms occur in smaller numbers, are more difficult to contact, and are more likely to be located outside the congestion charging zone.

## **FIGURE 2 ABOUT HERE**

The minimum recommended sample size for the survey (Czaja & Blair, 2005) was calculated to be 384 for a population size of 317,590 firms in London in 2005 (Prothero, 2008)<sup>31</sup>, assuming the recommended 95% confidence level, 5% margin of error, and a conservative response distribution of 50% implying maximum variance between responses. I prepared the questionnaire in consultation with representatives of several public and private organizations in London including the Center for Economic and Business Research, Federation of Small Businesses, the London Chamber of Commerce and Industry, Economics unit of the Greater London Authority, and the London office of the Confederation of British Industry.

I hired the services of a London-based survey research company to conduct the fieldwork using their trained interviewers, call centers, and Computer-Aided Telephone Interviewing (CATI) software to track and record responses. I worked closely with the survey team through the stages of deciding the sampling strategy, drafting the questionnaire, obtaining the sample, pre-testing the questionnaire with specific instructions on how to ask the questionnaire items, and revising the questions after pre-testing. Following this period, I remained in contact with the

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<sup>31</sup> Transport for London (2006) reports the number of business units in Greater London as 365,126 in 2006. The number reported by Prothero (2008) in the GLA report is slightly lower. However, the sample size required for the survey is not sensitive to the population size if the latter is sufficiently large (Czaja and Blair, 2005) – in this case, a population size >120,000 would require the same sample size.

survey team by telephone through the period of data collection. The survey resulted in 399 complete responses that I used for the statistical analysis. Each interview was on average 15 minutes in length, shorter for financial and business services firms, and longer for firms in all other sectors because they were asked specific operational questions related to their freight transport. A structured instrument comprising about 25 questions was prepared after pre-testing with 10 respondents. The target respondents for the survey were senior managers at the firms, specifically those with responsibility or knowledge of the firm's transportation operations. Firms listed in the sample were contacted randomly and if there was no answer or the appropriate respondent was not available, they were contacted again for an interview. Response rates varied by sector; for example firms in the low technology manufacturing sector were most difficult to contact while those in wholesale and retail were the easiest to contact. Some of the reasons for non-response included refusal to participate in any type of survey, lack of time, and unavailability of appropriate respondents.

### **3. Theoretical Framework**

This research builds on a conceptual framework I proposed in prior work on the expected impacts of road pricing on firms in the Netherlands (Mahendra, 2008), where legislation to implement nationwide road pricing will be enacted in 2011. The research was an ex-ante study of the impacts firms *expect* to face when road pricing is implemented and it included a scenario representing urban congestion pricing. In that study too, I had interviewed firm managers, asking open-ended questions to understand all possible factors that might determine the impact of congestion pricing on a firm and what its response might be. Through an ex-post analysis, the present study contributes to further development and testing of those concepts in the London case, where congestion pricing has been in effect for five years.

Empirical studies (CfIT, 2003; Quddus et al., 2007; Whitehead, 2002) and monitoring reports produced by Transport for London (2004-2007) indicate that the impacts of the congestion charge are likely to vary by sector, size and location of business. In my research mentioned above, I found that the effects of these variables are mediated through institutional and operational conditions that play an important role in determining business impacts. In other words, the institutional and operational conditions help analysts understand how and why a firm's size, sector, and location dictate the impacts it faces. A relevant theory that may explain how a firm adapts to changes in its environment is the resource dependency theory (Cox et al.,

2002; Hrebiniak & Joyce, 1985). It helps analysts understand the power-dependence relations between firms that are discussed extensively in organization theory literature and that suggest how firms might be impacted as a result of road pricing policies [see Mahendra (2008) for a detailed discussion].

To test some of the propositions in my earlier research, in this study I quantify the importance of different factors in determining the impacts of the London congestion charging scheme on small and medium enterprises (SMEs) located in the city. The types of impacts include changes in the operations, accessibility, and profitability of SMEs in key sectors of the London economy. I selected the variables in the survey from a thorough review of the literature and from the findings of the earlier qualitative study.

I measure the impact of congestion pricing on firms in London through a change in their turnover, a common measure used in other surveys (Czaja & Blair, 2005; LCCI, 2005b; TfL, 2006). To explain the differences in impacts between firms, I examine factors categorized into firm characteristics, institutional variables, operational variables, and the perceived advantages and disadvantages of the congestion charge. Institutional factors are those that are typically not in the firm's control and are affected by policy, regulations, and market conditions. They include the power and dependence relations between firms (Cox et al., 2002) that play a role in determining the incidence of costs and impacts. Operational factors are those that can mostly be controlled by a firm, although the extent will differ by sector. The burdens and advantages that firms face from congestion pricing are likely to explain the impact on turnover and will cause firms to respond in specific ways.

Figure 3 shows an assumed causal framework that is used for the analysis. In this framework, variables are ordered along a probable temporal sequence, a common approach followed in studies that attempt to identify factors responsible for a particular outcome. The framework comprises the categories of independent, intervening, and dependent variables, and variables relating to firm response to congestion charging in London. For each category, the figure lists the variables for which I obtained data through the telephone survey.

It is difficult to specify causal or temporal relationships between variables within each category but more straightforward to specify a temporal order across categories or blocks of variables. I hypothesize that each of the variables included in the framework has a direct or indirect effect

on the dependent variable, i.e., the impact of congestion charging on the turnover of the firm. For example, I expect that the economic sector a firm belongs to has direct effects on how it is impacted by congestion charging, but it may have indirect effects as well through layers of intervening operational variables. The independent variables within each block theoretically can affect the variables listed to their right.

### **FIGURE 3 ABOUT HERE**

Below, I elaborate on the different categories of explanatory variables, discussing their role in the causal framework. I also discuss variables that were not included in the causal framework but were useful for a descriptive analysis.

#### **3.1. Firm characteristics**

Firm size indicates the level of resources that a firm has. Smaller firms face greater pressures that threaten their survival, suggesting that small size may be a liability in situations where a firm must respond to changes in its environment (Goll, Johnson, & Rasheed, 2007). Sectors such as manufacturing, construction, and wholesale commonly exist as SMEs in London rather than as large enterprises (Prothero, 2007). A large firm may be better able to absorb the increased costs of congestion pricing than a smaller firm. While firm size can be conceptualized in terms of employees, scale of operations, or market share, empirically, one would expect these variables to be related (Chen & Hambrick, 1995).

The importance of sectoral or inter-industry differences has been widely recognized in industrial economics and industrial organization literature (Cohen, Levin, & Mowery, 1987; Klevorick, Levin, Nelson, & Winter, 1995). The firm's sector, along with the type of product it deals in determines much of its logistics strategy and operations. There is evidence that certain sectors, like transportation, may benefit from a road pricing policy (Mahendra, 2008a; Verhoef et al., 1998). However, this may not be only due to increased efficiency from travel time savings as Verhoef et al. predicted, but also due to the dependence of other firms on the transportation sector (Mahendra, 2008). In contrast, from a survey of the impacts of such pricing policies on freight carriers in the New York area, Holguin-Veras (2006) concluded that trucking firms do not have the market clout to pass on increased costs due to pricing policies to the shippers or receivers of goods. This suggests that firms in the transportation sector may be worse off than other sectors when congestion pricing is implemented. The wholesale and retail sector and the



construction sector may face negative impacts of higher charges because of lack of flexibility in the time during which they must transport goods. Travel times in these sectors are either dictated by customers or determined by regulatory constraints.

Another variable in this category that could play a role is the location of the firm, specifically whether it is located inside or outside the congestion charging zone. Location impacts are likely to occur since the all-day congestion charge exacerbates existing time restrictions on the delivery of goods in London. In addition, businesses may suffer location impacts owing to a reduced number of customers coming to their premises during charging hours. Location has been the control variable used by Transport for London in the impacts monitoring reports and I argue that this is not a reliable method because firms located inside the zone constantly do business with those located outside it. While location may be one of the factors responsible, it must not be used as the only control variable.

### 3.2. Institutional variables

Empirical findings from organization theory suggest that industry and firm-specific effects are both important in explaining different dimensions of firm performance (Porter, 1998a; Spanos & Lioukas, 2001). Previous research (Holguin-Veras et al., 2006; A. McKinnon, 2006) has indicated the effects of power differences between firms in determining the incidence of increased costs from congestion pricing policies. In exploratory research that was completed prior to this study (Mahendra, 2008), I use literature from organization theory to understand how firms may be differently impacted by congestion pricing depending on their power-dependence relations with other firms, the level of competition in their market which determines how easily they can raise their prices for customers, and the other constraints or local regulations to which they are subject. The research showed that power and dependence relations between firms are a result of firm characteristics, such as size and sector. Larger firms are expected to have greater power due to higher market share and commercial importance. Firms needing very specialized vehicles and equipment and that do not own their vehicles are expected to be more dependent on transportation firms. Finally, firms such as wholesale and retail that are location-bound face several other local constraints in urban areas, such as restricted timings for the delivery of goods and restrictions on the types of vehicles that can be used.

Institutional variables are expected to mediate the effect of firm characteristics on the dependent variable, i.e. perceived impact of congestion charging on turnover. In this study, I include

variables such as the firm's perception of its market conditions in broad terms of supply relative to demand and the extent of substitutability of its products or services in the local market, other local regulations that the firm is subject to, the level of specialization of transport requirements in terms of vehicles and handling, and the type of transport arrangement of the firm.

Market conditions and competition shape the prices firms can charge and the costs they have to bear (Porter, 1998b). These factors can constrain the ability of firms to raise prices to compensate for the congestion charge or to pass on the costs of the congestion charge downstream in the supply chain. I could not develop quantitative indices of level of market competition, such as the Herfindahl-Hirschman index and Lerner index, because these require data on market shares, sales, prices, and marginal costs for all firms included in the survey. This was not possible in the scope of my research; therefore I used a qualitative measure of competition. Prior research shows that firm managers act based on perceived levels of competition and the market. In fact, perceptions of the environment are perhaps more important than the actual environment in determining firm performance (Pagell & Krause, 1999). The greater the perceived level of competition, the greater is the need to control costs and increase efficiency (Khandwalla, 1973). A qualitative measure for the perceived intensity of market competition was used, adapting from other studies on the business environment of firms (Khandwalla, 1973; Pagell & Krause, 1999; Spanos & Lioukas, 2001). Another indicator of the firm's institutional environment that I used was the importance of other government regulations, a measure used by Pagell and Krause (1999).

Finally, to explore further the propositions developed in the earlier study (Mahendra, 2008) in which I applied the resource dependency theory to study the dependence of a firm on the transportation sector, I used a measure conceptualized from Cox et al.'s (2002) definition of dependence. This was the transport arrangement of a firm –i.e. whether the firm had its own transport, hired a transport firm, or had its goods transport arranged by its customer or supplier. If a firm had its own transport, its dependence on other firms was lower. A related measure assessed how specialized the firm's transportation needs were in terms of vehicles and handling. The higher the level of specialization, the greater the dependence, if the firm did not have its own transport.

### 3.3. Operational variables

As shown in the causal framework, the firm's operations occur within the institutional environment it is part of and are determined by its characteristics such as size, sector, product type, and scope of operations. The variables in this category dealt with the firm's typical transportation and logistics operations, including the time period of receiving and delivering shipments, the number of such shipments per week, and the location of the majority of the firm's customers and suppliers. An additional variable concerning employee impacts was also included, asking firms about the commuting profile of employees.

Firms that operate in a Just-in-Time context have more transport-intensive operations (Muilerman, 2001) and those that deal in perishable goods have more frequent shipments. In the day-to-day shipments that the firm receives and delivers, the locations of its suppliers and customers relative to its own location also play an important role. If a firm's supplier is located outside the zone while it is itself located inside the zone, then subject to the power and dependence relations discussed earlier, it may have to bear the costs of a congestion charge. There is qualitative evidence (CfIT, 2003) that suppliers charge firms in the zone surcharges for deliveries and small firms are unable to challenge these costs. Similarly, if the firm is located outside the zone but workers must travel inside the zone each day for business, as is the case with highly mobile workers in the construction sector, it is likely to face a negative impact. A firm may be negatively impacted by congestion charging if the policy constrains the accessibility for employees and customers. Finally, if the time period in which most of the firm's goods supply and delivery takes place coincides with the hours when congestion charging is in effect, then the firm has a higher likelihood of being negatively impacted.

### 3.4. Perceived Advantages and disadvantages

This block of variables refers to the advantages and disadvantages that firms reported to be facing as a result of the CC. Firms were asked to estimate whether their transport costs had increased or decreased as a result of the congestion charge, what the estimated percentage change in costs was, and who bore the incidence of the costs of congestion charging in the firm's operations. Regarding employee impacts, firms were asked if they had experienced higher staff turnover as a result of congestion charging, for which there is anecdotal evidence in some sectors in London.

### 3.5. Behavioral response variables

This set of variables included response options obtained from three sources: (i) analysis of prior open-ended interviews that were conducted to identify hypothetical responses of firms in different sectors to road pricing in the Netherlands (Mahendra, 2008); (ii) existing literature on expected and reported responses to road pricing in other countries (Holguin-Veras et al., 2006; A. McKinnon, 2006); and (iii) articles related to business response to congestion charging in London from trade journals of the specific sectors, from newspapers, and member surveys done by business organizations.

### 3.6. Attitudinal variables

To understand how attitudes toward the congestion charging policy differ among firms, respondents were asked two attitudinal questions—one about whether the firm was in favor of the congestion charge before it was introduced and two, the firm's current opinion of the congestion charging policy. The latter variable may be expected to influence and correlate with the perceived impact of the congestion charge on the firm's turnover, and therefore, acts as one of the validity checks for the dependent variable.

The categories of behavioral responses and attitudinal variables were not part of the causal framework tested in the next section because of the potential for reverse causality with the dependent variable, i.e., impact of the CC on firm turnover. In the next section, I provide some descriptive statistics broken down by sector and present the results of bivariate associations between the dependent variable and the explanatory variables.

## **4. Variables, Descriptive Statistics, and Bivariate Associations**

For each of the variables, I describe below the way it was operationalized in the questionnaire and I present the descriptive statistics. For several key questions, validity checks were included in the questionnaire in the form of related questions that could be used to test expected patterns of association (Fowler, 2002).

**4.1. Dependent variable:** To assess the impact of congestion charging on a firm, I constructed a categorical variable, based on a five-point response scale that measured the managers'

perception of the impact of the CC on the firm's annual overall turnover<sup>32</sup>. Responses were coded as (1) very positive; (2) positive; (3) neutral or no impact; (4) negative; and (5) very negative. Although respondents were asked about other impacts of the congestion charge later in the survey, such as changes in accessibility of customers, and in efficiency of transport operations, these changes are finally expected to affect the firm's turnover, positively or negatively. Therefore, impact on turnover was used as the dependent variable. This variable was measured subjectively rather than objectively, such that respondents provide their judgment of how congestion pricing has affected their turnover rather than measure the difference in annual turnover before and after congestion charging was introduced as in the TfL methodology. This was done because it is difficult to isolate the impact of the CC from differences in annual turnover. Other local and macroeconomic factors may play a role, providing inconclusive results as in the TfL reports (2004, 2005, 2006, 2007). Through their response, managers who are responsible for day-to-day decision-making provide their assessment of the overall impact on their firms which is important knowledge for decision-makers.

The assumption with using such an ordinal response scale is that, on average, firms that rate the impacts of the congestion charge as "very negative" perceive the impacts to be worse than those who rate them as "negative" and so on, along the continuum. However, the difference between any two adjacent scale values is not expected to be the same. Although people may differ in their criteria for "negative" and "very negative" impacts, the ordinal scale still provides a meaningful mode of measurement and is probably the most prevalent kind of measurement in survey research (Fowler, 2002). Figure 4 shows the distribution of the dependent variable in the full sample and Figure 5 shows the distribution by sector. Only about 3% of firms in the sample reported positive or very positive impacts on turnover as a result of congestion charging and these were from the transport, restaurants, and finance and business services sectors. 53% of firms reported negative or very negative impacts, and 44% reported neutral or no impact of the congestion charge on turnover.

**FIGURE 4 ABOUT HERE**

**FIGURE 5 ABOUT HERE**

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<sup>32</sup> The business term "turnover" commonly used in Europe is defined as the annual revenue that a firm receives through the sale of its products and/or services to customers in a given period.

I tested the validity of this measure by providing two other questions in the survey whose responses should correlate with it. Following the methods explained by Fowler (2002) and Singleton and Straits (1999), I estimated validity by the extent to which responses on the dependent variable were associated in expected ways with responses to other questions assumed to be related to the dependent variable. The variable met multiple criteria of validity, as discussed in Singleton and Straits (1999).

To enable analysis, I combined the small number of responses in the categories “positive impact” and “very positive impact”, with the category “neutral or no impact” to form a new category called “no negative impact”. Therefore the dependent variable used for analysis in the rest of the paper had three categories ordered by intensity of negative impact on turnover and coded as: (1) no negative impact; (2) negative impact; and (3) very negative impact.

#### **4.2. Independent or explanatory variables:**

For each of the following independent variables, I conducted bivariate analyses to identify whether the variable had a statistically significant relationship with the dependent variable. For all nominal variables, I used the  $\chi^2$  test of significance (Babbie, 2001; Bryman & Cramer, 1995; Singleton & Straits, 1999) and for ordinal and ratio scale variables, I tested the statistical significance of the appropriate correlation coefficients<sup>33</sup>. Descriptive statistics for each variable, reported by sector, along with the results of bivariate tests of association with the dependent variable are shown in the table in Section II of the Appendix.

##### Block 1: Firm characteristics

This group of variables includes indicators of firm size measured in terms of the *number of employees* and *annual sales* that were obtained from business databases. These are commonly used measures for firm size (Price & Mueller, 1986). Other indicators I used to measure firm size include the *number of locations* the firm has in London, and its *annual expenditures on road transport*. Respondents were also asked about the *geographic scale* of the majority of the firm’s operations, i.e. whether local, national, or international, also used in some studies (M. Chen & Hambrick, 1995). Figure 6 shows the distribution of the surveyed

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<sup>33</sup> In this study, the dependent variable (DV) is ordinal, ordered by the intensity of negative impacts on turnover reported by a firm (“no negative impact”, “negative impact”, “very negative impact”). I used the  $\chi^2$  statistic to test the statistical significance of a relationship between each nominal independent variable (IV) and the DV. To test the relationship between each ordinal IV and the DV, I looked at the statistical significance of the Spearman rank correlation and Kendall’s rank correlation. To test the relationship between each ratio scale IV and the DV, I looked at the statistical significance of Pearson’s product-moment correlation coefficient (Singleton & Straits, 1999; Zikmund, 1991).

firms by size, measured as number of employees, and by sector. With respect to firm size, firms in the “micro” category having less than 10 employees at the respondent’s location represent the largest share of firms that were surveyed. 75% of the surveyed firms were from the services, wholesale and retail, and restaurants sectors that have the largest representation in London. Figure 7 shows annual expenditures on road transport among firms, by sector. The transport, construction, and manufacturing sectors have the highest share of transportation expenses in their operations, while restaurants have the lowest share.

**FIGURE 6 ABOUT HERE**

**FIGURE 7 ABOUT HERE**

The *economic sector of the firm* was determined from its UK SIC (2003) code listed in the sample database. Respondents were also asked to report the sector. In some cases, there was a discrepancy between the sector of the firm as listed in the UK SIC codes and the sector of the firm as reported by the respondents. This was mostly seen in firms where a product and a service were offered together from one location: for example, a picture framing shop was listed in the UK SIC codes for Low Technology Manufacturing but the respondent mentioned it as a retail firm, a bookstore was listed as part of the publishing sector in Low Technology Manufacturing, and an interior design store that also sold products was listed as a services firm in the UK SIC codes. However, since products were also sold at all these locations, we classified the sectors of these firms according to the self-reported sector by respondents, i.e. retail, defined as a sector where goods are sold directly to consumers. If, however, no products were sold to customers from the location, the UK SIC code was maintained. For all cases where there was such a discrepancy, I obtained further information about the main business of the firm from its website and classified the sector as appropriate. In the dataset finally used for analysis, the correlation between the sector listed in the UK SIC codes and the self-reported sector of the firm is 75% (statistically significant at the 99% confidence level).

Firms were also asked to report their *main products or services*. Additional firm characteristics used as independent variables were the *firm’s location* specified by post code to check whether it was inside the central London congestion charging zone, the western extension, or outside the combined zone, and the *number of locations inside the congestion charging zone*. This variable was included to allow comparisons between this research and the majority of other studies of the London congestion charge that use firms located outside the congestion charging

zone as a control group to measure impacts of congestion charging. The location of the firm was not found to have an independent association with the impacts experienced due to congestion charging. However, as I will show later, the location variable emerged significant in the presence of other variables.

### Block 2: Institutional and operational variables

Following the causal framework, I specified independent variables that describe the firm's institutional environment, mainly the firm's perception of market conditions and the level of competition. The perceived intensity of market competition has been measured in multiple-item scales in prior studies where it was the key variable of interest (Chong & Rundus, 2004; Khandwalla, 1973; Mia & Clarke, 1999). I could not include multiple items in this study because the length of a telephone interview is necessarily limited. However, I used these as a guide for conceptualizing perceived competition in this study. I operationalized market competition in terms of two key dimensions—(1) the substitutability of a firm's product or services (Cox et al., 2002; Porter, 1998a; Spanos & Lioukas, 2001) and (2) the number of competitors (Pagell & Krause, 1999; Porter, 1998a)—by asking respondents if their customers could easily find the products and services they offer at other competing local businesses. Responses were coded as yes (1) or no (0). To operationalize firm power, following Cox et al. (2002) and Mahendra (2008), I used firm size and annual expenditures on transportation as indicators. Firms were also asked to compare the constraints they faced from congestion charging to other local regulations that applied to them. The assumption here, as in other studies, is that the respondent, being at a managerial level, is knowledgeable about the institutional environment of the firm. This was confirmed through pre-tests of the questionnaire.

According to Porter (1998), the balance between supply and demand in a sector can determine the profitability of a firm. In prior research (Mahendra, 2008), this balance between supply and demand was often mentioned when I asked firm managers to explain how the costs of congestion pricing policies would affect their firms. For instance, if there was a shortage of supply in the transportation sector, while demand was high, firms expected to raise prices for customers in spite of the levels of competition in the industry (Mahendra, 2008). To assess the effect of market conditions, respondents were asked which of the following were true in their market in the past year: (i) supply has been higher than demand; (ii) demand has been higher than supply; and (iii) supply and demand have been fairly equal. Having pre-tested this question prior to conducting the survey, I found that it was well understood.



I adapted the questions to measure operational variables from interview-based studies done by Muilerman (2001), Holguin-Veras (2006), and Whitehead (2002). Firms that provided their own transport were asked how many vehicles they owned. Freight –related transport intensity was measured by the weekly numbers of shipments received from suppliers at that location and shipments delivered by the firm to customers. Firms were also asked about the location of the majority of their customers and suppliers—i.e. whether these were located inside the combined central and western congestion charging zone, outside the zone but in London, or outside London. They were asked whether the time period during which most of their goods supply and delivery takes place was before congestion charging hours (before 7am), during congestion charging hours (between 7am and 6pm), or after congestion charging hours (after 6pm). Regarding employee accessibility, respondents were asked to estimate the percentage of employees who used a car to commute to work. The responses were coded as none, less than 10%, 10-25%, 26-50%, 51-75%, and more than 75%. Since this was a complex question requiring a calculation by the respondents, I tested its validity by studying the expected patterns of association with other variables. As expected, the location of a firm outside the congestion charging zone was positively correlated with a higher proportion of employees using private transport to commute to work and a location inside the central or western zone was correlated with lower proportions of car-commuting employees (statistically significant at the 95% confidence level).

### Block 3: Advantages and disadvantages of the congestion charge

Using information from literature (CfIT, 2003; A. McKinnon & Woodburn, 1996; Runhaar, 2002; TfL, 2007), lists of advantages and disadvantages were read to respondents, asking them which ones their firms had faced as a result of the congestion charge. These were coded as dichotomous variables with values yes (1) and no (0). Figures 8 and 9 show the proportion of respondents in each sector that mentioned each advantage and disadvantage. Respondents were also asked whether their firms had faced a higher staff turnover as a result of congestion charging, coded as yes (1) or no (0). The figures indicate the differences in advantages and disadvantages of the congestion charge as perceived by firms in each sector. A higher percentage of the surveyed firms in each sector reported disadvantages of congestion charging than advantages. The fact that travel delays have not actually reduced was a disadvantage reported by 40-50% of firms across sectors. More expensive access for customers, visitors, and employees, higher business costs, and increased administrative or operational burdens were other key disadvantages reported by firms. Advantages of congestion charging were

reported by about 10-20% of firms across sectors. The advantages included improved public transport, improved access for customers, visitors, and employees, and faster travel.

**FIGURE 8 ABOUT HERE**

**FIGURE 9 ABOUT HERE**

#### Behavioral response variables

Response measures were created after a review of the reports on the London congestion charging scheme and other literature reporting on behavioral responses to road pricing in contexts other than London (Holguin-Veras et al., 2006; A. McKinnon, 2006). These variables were created by asking respondents what decisions they had already taken or expected to take in order to deal with the congestion charge. The responses were coded as (1) already taken; (2) might take in the future; and (3) not taken or not applicable. The options given to respondents asked if they had moved any premises outside the congestion charging zone, reduced business with customers in the zone, made their transport more efficient, changed their vehicle type, or changed their suppliers. Regarding transport arrangements, respondents were asked if they had changed their transportation company or brought more of their transport operations in-house—both options only provided to firms that did not have their own transport. If firms did have their own transport, they were asked if they had contracted out more of their transport operations to deal with the congestion charge. Figure 10 shows the decisions firms had already taken in response to the congestion charge, distributed by sector. The key decisions firms had taken were to increase the efficiency of their transport operations, to reduce business with customers inside the congestion charging zone, to change suppliers possibly because of problems with original suppliers not wanting to deliver goods inside the congestion charging zone, or to change their vehicle type because vehicles with very low emissions are not required to pay the congestion charge. Some firms, mostly in the manufacturing sector, had also begun to carry out their transport operations themselves, rather than contract them out to a transportation firm.

**FIGURE 10 ABOUT HERE**

#### Attitudinal variables

The first question in this set asked respondents to recall if their firms had been in favor of the congestion charge before it was implemented, with responses coded as yes, no, or neutral. The

reliability of this response would clearly depend on the tenure of the respondent in the firm, specifically if the respondent had been an employee for at least five years and worked for the firm prior to 2003 when the congestion charge was first introduced in central London. I did not have this information. The second question asked about the firm's current opinion on the congestion charge and was coded on a 5-point response scale with options "very positive", "fairly positive", "neutral", "fairly negative", and "very negative". The correlations between these variables measured by sector and business location revealed how a firm's position had changed before and after the congestion charge was implemented.

#### **4.3. Specification and Estimation of the Ordinal Logistic Model**

Given the ordinal categories of the dependent variable, I estimated a multivariate ordinal logistic regression model to understand the factors that may explain whether or not a firm is negatively impacted by congestion pricing. This is the recommended technique when the outcome or dependent variable is measured in categories which can be ranked but the distance between categories is unknown (Borooah, 2002; Long & Freese, 2006). Variables with ordinal outcomes are often used in cross-sectional survey research, for example, when people are asked to report their health status as "poor", "good", or excellent", where the outcomes take values 1, 2, and 3 respectively. The distance between poor and good is not assumed to be the same as that between good and excellent and the key criterion is that stronger outcomes are represented by higher values (Borroah, 2002). This is in contrast to linear regression models that assume the distances between categories to be equal. In this study, I measured the dependent variable as the intensity of negative impacts on turnover as a result of congestion charging, coding it with three values: 0 - "no negative impact", 1 - "negative impact", and 2 - "very negative impact"<sup>34</sup>.

Logistic regression is more flexible than other techniques of statistical analysis because it has no assumptions about the distributions of the explanatory variables— i.e. they do not have to be normally distributed, linearly related, or of equal variance within each group. In the technique of hierarchical regression that I followed, variables are entered into a regression model based on logical or theoretical considerations, such that independent variables presumed to be causally prior or of greater theoretical importance are entered into the equation earlier. The variables

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<sup>34</sup> This variable was actually measured as a Likert item with the commonly used five response categories (Babbie, 2001; Singleton & Straits, 1999), measuring the intensity of negative impacts of congestion charging on the firm's turnover. The response categories were: (1) Very positive; (2) Positive; (3) No impact or neutral impact; (4) Negative; and (5) Very negative. In Ordered Logistic Regression, an outcome category with a small number of cases may be merged into an adjacent category (Long, 1997). Due to the very small number of responses in categories 1 and 2 (see table CCC), categories 1, 2, and 3 were combined to form a new category representing "No negative impact".

can be entered one at a time or in blocks (Tabachnick & Fidell, 2001) and the degree of relationship between the dependent and the independent variables is assessed at each step of the hierarchy when a new independent variable is added. I followed the model-building strategies outlined by Hosmer and Lemeshow (1989). I also conducted the appropriate diagnostic tests and goodness-of-fit assessments of the model recommended by Long and Freese (2006), Long (1997) and Chen et al. (2003) for all versions of the model specified. As is common in survey analysis using social data, some independent variables in the dataset have low to moderate levels of multicollinearity between them, up to a maximum of 0.43 that does not compromise the model. The step-wise addition of blocks of variables to the regression model is shown in the table in Section III of the Appendix. I included sector-specific fixed effects in the model for completeness; however, the sectors are not themselves responsible for the impacts, it is the attributes of firms in certain sectors that determine impacts. The final specification of the ordinal logistic model is shown in Table 2. I estimated the model and the resulting odds ratios using the statistical software Stata (version: Intercooled Stata 8.2 for Windows). The findings from the model are discussed in the next section.

## **TABLE 2 ABOUT HERE**

### **5. Results and Interpretation of the Model**

Strictly speaking, what we can infer from non-experimental empirical data such as that obtained from the survey is association between variables and not causation (Tabachnick & Fidell, 2001). But even though a regression equation does not *demonstrate* that an independent variable X is a cause of the dependent variable Y, a non-zero coefficient X is at least *consistent* with a causal effect on Y (DeMaris, 2004). Regression analysis must always be based on a theory of expected effects. Then the regression coefficients can be considered as the “effects” of the independent variables on the dependent variable with some degree of confidence, provided that the findings are treated as preliminary and tentative. I discuss my interpretations from the model, with this caveat in mind. The variables discussed are those that were found to be statistically significant at the 95% confidence level.

### **5.1. Effects of firm characteristics**

As shown in Table 2, the odds of experiencing more negative impacts of congestion charging<sup>35</sup> on turnover decrease by about 19% for an increase in annual sales (in Pounds Sterling, GBP) by 1 million, holding all other variables constant. This reflects the role of firm size measured in terms of sales. Larger firms face less negative impacts. If a business primarily has local operations as compared to national or international operations, the odds of experiencing negative impacts on turnover due to congestion charging increase. Businesses that exclusively have local operations have about six times greater odds of facing negative impacts from congestion charging compared to those that have national operations, holding all other variables constant. Alternatively, a business with national operations had 0.17 times ( $\text{odds}_{\text{national}}/\text{odds}_{\text{local}} = 1/6$ ) or 83% smaller odds of facing negative impacts from congestion charging. Some of the medium-sized and large-sized retail firms and those in the financial services that do not have exclusively local operations are therefore, less likely to have faced negative impacts from congestion charging. Such firms employ a significant proportion of London's population (Prothero, 2008).

Another important variable is the location of the firm. The odds of negative impacts are 7.3 times larger for firms located inside the central London congestion charging zone and about 5.8 times larger for firms located in the western extension of the zone, as compared to firms located outside the combined congestion charging zone, controlling for all other variables. This contradicts the Transport for London finding that there are no differences in firm-level impacts inside and outside the CC zone. A higher reliance on road transportation measured in terms of average annual expenses on road transport, controlling for firm size, is associated with larger odds of negative impacts due to congestion charging. Firms in the construction, manufacturing, and transportation sector were likely to have a higher share of transportation expenditures than firms in the restaurants, wholesale and retail, and services sector. The data showed that after the transportation firms, the construction firms had the highest annual transportation expenses and restaurants had the lowest transportation expenses.

The sector of the firm is moderately correlated with some of the institutional and operational variables. This is bound to occur because firms in the same sector often have similar operational characteristics. For example, restaurants are much more likely to have primarily

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<sup>35</sup> Wherever the phrase “negative impact of congestion charging” is used in this section, it refers to the dependent variable measured in the survey and used in the regression model – the perceived extent of negative impacts of congestion charging on a firm's overall turnover.

local operations as compared to firms in the finance and business services sectors. Also, restaurants are more likely to have the transport of goods arranged by other firms they do business with (such as suppliers and wholesalers) than firms in the construction sector that often arrange their own transportation. Due to correlations, the standard errors are high on the sector variables making their coefficients less robust. Still, most of the coefficients are statistically significant at the 95% confidence level (services sector at 90% confidence level), making interpretation of relationships possible and justified for the sample considered. A firm's sector is an important determinant of impacts, as expected. Across all versions of the model that I estimated, the transportation sector is the least likely to experience negative impacts. Firms in the low technology manufacturing sectors, such as printing and publishing, food products, wood and metal products, and apparel, have the highest odds of negative impacts, followed by those in wholesale and retail, construction, restaurants, and services sectors, in that order.

## **5.2. *Effects of institutional and operational variables***

With regard to market conditions, firms reporting higher supply in their markets than demand have almost double the odds of facing negative impacts as compared to those reporting equal supply and demand. The majority of firms reporting relatively higher supply are in the restaurants sector. Firms in the restaurants and transportation sectors also report a higher level of local competition than the other sectors, but this variable is not found to be statistically significant in the regression. Firms reporting that the constraints of the congestion charge are more significant for them than other local regulations they are subject to have almost double the odds (92% higher) of facing negative impacts of congestion charging. A look at the descriptive statistics in Section II of the Appendix shows that the highest proportion of these firms is in the wholesale and retail sectors. These sectors face several location-based restrictions on freight transport, as discussed earlier.

The specialization of a firm's transportation requirements, in terms of vehicles and handling, is found to be a statistically significant predictor of negative impact of congestion charging. Higher specialization is associated with 67% higher odds of negative impacts due to congestion charging. The effect of specialization depends on vehicle ownership. A firm that does not have its own vehicles and requires specialized transportation is more dependent on a transport firm. Firms in the construction sector and those in low technology manufacturing, especially those dealing in food products, are most likely to require specialized transportation, and had the

highest annual expenditures on transportation. This suggests a relatively stronger reliance of these sectors on road transport.

The variable measuring the incidence of the congestion charge shows expected signs in the model. Firms are less likely to experience negative impacts of congestion charging in cases where a hired transport company or a supplier pays the costs of the congestion charge, as compared to cases where the firm or its customers pay the charge. About 19% of firms have more than one type of entity paying the charge in their supply chain, suggesting that the incidence of the charge varies with different business partners. This makes it difficult to ascertain the magnitude of impacts on any one firm.

Accessibility impacts were confirmed through this model, not only through the firm location variable discussed earlier but also through the variable “percentage of employees commuting to work by car.” Holding all other variables constant, a high percentage of employees driving to and for work is associated with higher negative impacts of congestion charging. The construction sector, low technology manufacturing sector, and transportation sector have a high proportion of their employees driving to and for work. The construction and manufacturing sectors are also most likely to be located outside the congestion charging zone.

### ***5.3. Effects of Advantages and Disadvantages from Congestion Charging***

The effects of congestion charging on a firm’s turnover can be assessed by studying the advantages and disadvantages that firms reported to be facing from the congestion charge in London. I report the advantages and disadvantages that have a statistically significant association with the impact on a firm’s turnover. Firms that reported higher staff turnover had about 5 times greater odds of being negatively impacted and those that reported a need for additional labor to obtain or deliver goods had about 7 times greater odds of experiencing negative impacts due to congestion charging. Other disadvantages reported by firms that are statistically significant in determining negative impacts were higher transport costs and the fact that congestion had not reduced. Firms reporting that it had become more expensive for their customers, visitors, and employees had 2.6 times greater odds of being negatively impacted, indicating the impact of congestion charging on accessibility. Firms that had been able to pass on the costs of the charge to other firms or to consumers had about 80% lower odds of experiencing negative impacts due to congestion charging in London.

I also included two attitudinal questions in the survey asking whether a firm had been in favor of the congestion charge before its implementation, and what the current attitude of the firm was towards the congestion charge. About 35% of firms had either a neutral or positive opinion about the congestion charge, both before it was implemented and at the present time. But what is interesting is the way these proportions changed among the sectors. The construction and transportation sectors had the highest proportion of firms that had changed their opinion of the congestion charge and were less positive about it at the present time. On the other hand, restaurants had a more positive opinion of the congestion charge now than prior to implementation. This may relate to the change in the timings of the charge, implemented in 2007 such that it now ends at 6:00 pm rather than 6:30 pm. This change was made to alleviate negative impacts on the restaurant sector.

## **6. Conclusions and discussion**

The subject of congestion pricing is often considered controversial with strong arguments in favor of it and against it. Supporters consider the policy necessary for optimal allocation of resources and sustainable demand management, while opponents consider it simply another form of taxation. These conflicting views and some misconceptions regarding the impacts of the policy make it necessary to study cases of implementation and to objectively document the impacts on different segments of users (Hoguin-Veras, 2006). There is scarce evidence regarding the economic impacts of urban congestion charging schemes from Singapore and Norway—the only countries where charging schemes have been in operation long enough for impacts to become apparent (Whitehead, 2005). The impacts of urban congestion charging on businesses and the urban economy are often ignored and represent a critical gap in knowledge. These impacts must be conceptualized and assessed in a very different manner from the impacts on car commuters and passengers. This is because of the existence of significant institutional and operational constraints that do not allow firms to make changes in travel time, route, or mode the way commuters can.

The main reason some firms in London are facing negative impacts from congestion charging is because the accessibility impacts of the charge and the direct and indirect costs associated with it do not balance out the advantages of reduced travel delays and improvements in public transport. Although a small proportion of firms did mention experiencing these advantages, the proportion that experienced disadvantages from the policy was far greater. The fact that almost



92% of firms had their deliveries occurring during congestion charging hours is important. It shows how the all-day congestion charge that has been implemented in London could have detrimental effects on economic activity and on businesses that bear the incidence of these costs.

Additionally, of the firms that responded to my survey, about 64% of those located inside the zone had their main customers or suppliers located outside the congestion charging zone and about 42% of firms located outside the zone had their main customers or suppliers located inside the zone. This indicates that businesses located both inside and outside the zone are likely to be impacted by congestion charging. Because the London congestion charge is a location-specific policy that applies in the key shopping, entertainment, and business districts of the city, firms appear to suffer accessibility impacts on the demand side as well as the supply side. Thus, the type of congestion pricing policy has important economic impacts. Overall, it appears that at least in the context of businesses, the London congestion charge achieves lower welfare gains than would be possible with a system where travel costs are differentiated based on the distance traveled and the time of travel (Peirson & Vickerman, 2008). The full social costs incurred by the use of roads are determined by these factors and although it is difficult to achieve in practice, congestion pricing must reflect these costs to the extent possible.

Key findings from the survey are as follows:

- 1) The location of a firm is an important determinant of the impacts that it faces from congestion charging. Contrary to conclusions from the Transport for London reports, firms located inside the congestion charging zone were found to experience more negative impacts from the policy. The location impacts are primarily caused by reduced accessibility resulting from higher costs.
- 2) The impacts of firm size are not as significant. Larger firms and those with predominantly non-local operations are less likely to face negative impacts from congestion charging, but location and sector impacts are more significant.
- 3) Strong sectoral impacts are found. Holding all other variables constant, firms in the low technology manufacturing, wholesale and retail, construction, and restaurant sectors were found to experience more negative impacts of congestion charging. Firms in the transportation sector were least likely to experience any negative impacts because they can pass on the charges to customers, while gaining from any travel time savings. In the services sectors, the results from the model were less conclusive, possibly because I

combined the finance and other services sectors into one category. Finance services firms tend to be larger with national or international operations. Business and household services firms tend to be smaller with more local operations. Comparing these findings with those of other empirical studies, summarized in Table 1, it is evident that the restaurant and retail sectors have faced some loss in business, and the smaller firms have particularly suffered due to the increase in costs; however, the transportation sector does benefit from the congestion charge. The CfIT (2003) and FTA (2004) conducted early surveys of the freight transport and logistics firms, both producing fairly contradictory results. The findings of this study are more in line with the CfIT survey that showed greater support for the congestion charge among logistics firms. Other sectors covered in this study such as construction and manufacturing are not discussed in other studies.

- 4) The impacts on each sector can be explained by the institutional and operational variables in the following ways:

Firms in the construction sector typically have high transportation intensity and provide their own transportation. The majority of firms in the low technology manufacturing sector also have their own transport which tends to involve specialized vehicles and handling. Firms in these sectors thus have higher transport expenditures and are predominantly located outside the congestion charging zone. The construction sector has operations concentrated in the local area with highly mobile workers who travel in vans during congestion charging hours.

Although in some cases, charges are paid by customers or suppliers, the majority of firms in all sectors except for the transportation sector, paid the congestion charge themselves, resulting in reduced profitability. Firms in the transportation sector are least vulnerable to negative impacts because of the ability to pass on the charge to customers. This supports the result from Mahendra (2008) that transport firms may have greater market power because other firms, especially small firms, depend on them for freight transport. If transport firms gain from travel time savings, these gains do not appear to transfer to their customers—firms that are the shippers or receivers of goods. Restaurants primarily suffer accessibility impacts from a reduced number of customers in an institutional environment of high competition and supply from other similar firms and highly local business operations. Other factors matter less because restaurants have among the lowest transportation expenses. Transportation of food products is arranged by suppliers who are typically located outside the congestion charging zone, or customers, who are likely to pay for the congestion charge.

Firms in the wholesale and retail sectors also appear to suffer accessibility impacts both on the supply side and the demand side. They have relatively low transportation expenses and are able to benefit from improved public transport, but they face high constraints in terms of restricted times for the supply and delivery of goods. Finally, impacts on firms in the services sectors varied by the business of the firm. Overall, the financial and business services sectors had low expenditures on transport and operations that are not concentrated in the local area even though they are most likely to be located inside the congestion charging zone. They have the lowest transport intensity and are able to obtain benefits from improved public transport, experiencing a less negative impact than other sectors.

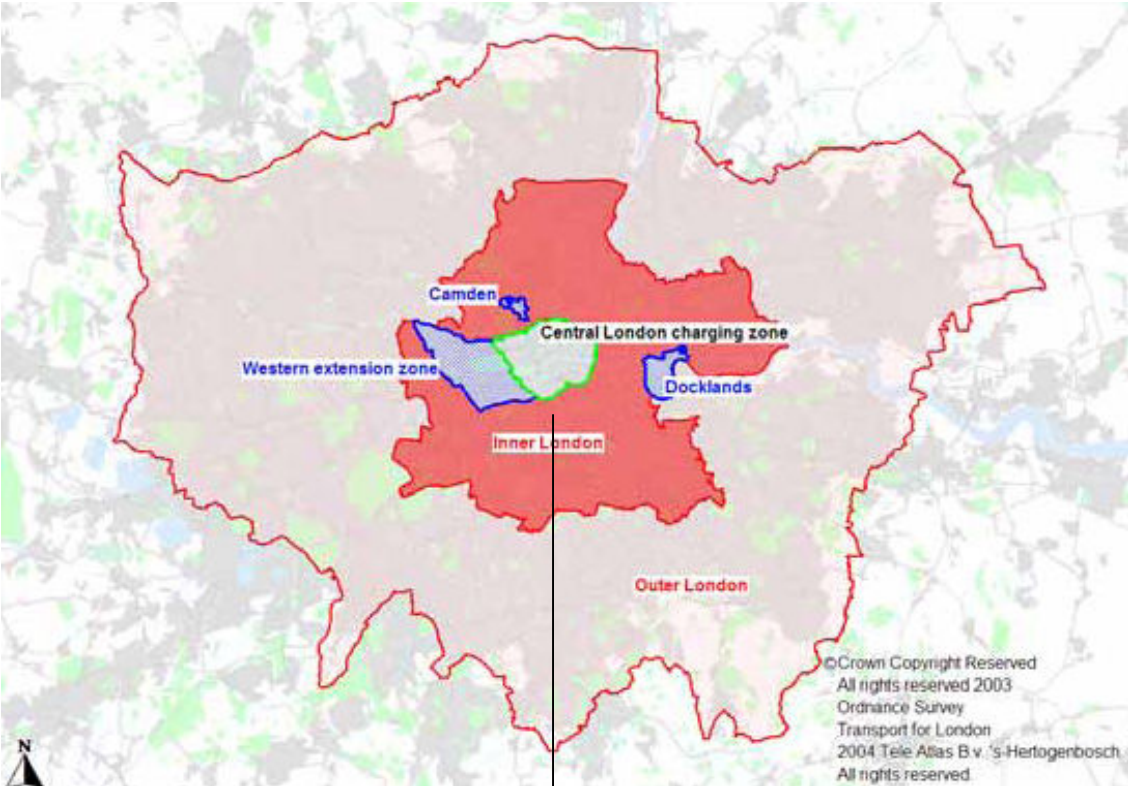
At the end, it is important to discuss some limitations of this research. The number of responses received in the categories of “positive impacts” and “very positive” impacts was too small for these to be considered individually in the analysis. This may be because very few firms actually experienced positive impacts as a result of congestion charging. However, given that congestion charging is a controversial policy, we cannot rule out the social desirability bias (Babbie, 2001) arising from respondents answering questions in the manner they believe the interviewer wants them to. Respondents sometimes respond strategically in order to send an implicit message to the authorities. There is also some evidence to show that the inclusion of a middle category, in this case, “neutral impacts” sometimes draws responses away from the extreme categories (Presser & Schuman, 1989). Additionally, a response bias may be present such that respondents choosing to answer the survey had a special interest in the topic (Fowler, 2002). Social surveys are often subject to these biases, making it difficult to generalize the findings. But in this case, my aim was not to estimate the proportion of all firms in London that were being negatively impacted from congestion charging, but rather to identify what types of firms were more or less likely to face negative impacts of the policy and why. Because I am most interested in the relationships among variables, these biases, if present, do not seriously threaten the validity of the findings. For key variables such as the dependent variable, I included correlated questions in the survey to check for validity of the responses.

The measure of congestion charging impact that I used is also a possible limitation of the survey. I used a self-reported, perceptual measure of the impact of the CC on turnover, because turnover ranges would vary among firms in different sectors and of different sizes. Therefore, changes in turnover obtained from databases would have been of limited value in making comparisons across multiple sectors. A perceptual measure may not fully capture

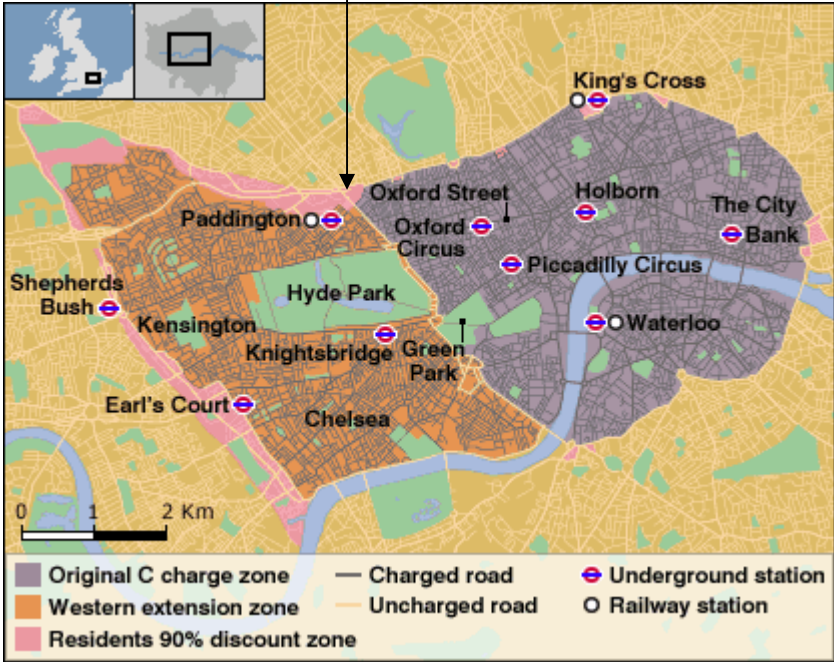
actual impact on turnover due to inaccurate perceptions of firm managers. However, an imperfect perceptual measure was preferable to having no measure of firm-level impact at all or to using aggregate measures as in the TfL methodology. Variables indicating social phenomena are often difficult to measure. One such variable that I did not explore was the effect of cooperation or alliances between firms in determining the impacts of congestion charging. For instance, transportation firms often subcontract and cooperate with other firms to increase the efficiency of their operations. This may be an institutional factor that explains the more positive effects of congestion charging on firms and must be considered in future research.

This study helped demonstrate the relationships between several factors that might explain the impacts of congestion charging on businesses and economic activity in London. However, one such cross-sectional survey cannot show how widespread those relationships are (Punch, 2003)—a question that must be considered in future research.

**Figure 1. Maps showing the combined central London congestion charging zone and the western extension in the Greater London Area**



Source: Transport for London, Congestion charging – Fourth Annual Impacts Monitoring Report (2006)



Source: BBC News, "Congestion charge zone increases" (2007)

**Table 1: Summary of Most Recent Studies reporting Impacts of Congestion Charging on Firms in London**

Sponsor/author	Study title	Year(s)	Data/method	Evidence
Transport for London (TfL)	Congestion Charging: Fifth Annual Monitoring Report	2007 (annual studies 2003-2007)	Compared business performance inside and outside CC zone, measured by number of businesses, employees, and sales/profits.	No discernible positive or negative effects of congestion charging: impact is broadly neutral. In retail sector, changes in overseas visitors and in consumer spending are responsible for any negative effects on business activity.
London Chamber of Commerce and Industry (LCCI)	The Third Retail Survey: Eighteen Months On	2005 (earlier studies done in 2003 and 2004)	Postal survey of 330 randomly selected retailers	Substantial negative impact on the retail sector. 84% of retailers reported a fall in takings. 63% reported a fall and 5% reported a rise in customer numbers. 62% of those reporting a fall in customers or takings considered the CC mainly responsible for the impact rather than a slow economy, fall in tourism, or fear of terrorism. 37% of respondents had a fall in staff levels, 18% changed opening hours because of the CC, and 33% were considering relocating outside the zone.
	Restaurant Survey	2004	Postal survey of 212 randomly selected restaurant owners	75% of restaurant owners surveyed reported a fall in takings with the majority considering the congestion charge responsible over a fall in tourism or fear of terrorism, 43% had a fall in staffing levels, 35% were considering relocating, and 20% were considering closure of business.
Commission for Integrated Transport (CfIT)	The Impact of Congestion Charging on Specified Economic Sectors and Workers	2003	Qualitative data from interviews with 103 firm managers in total	<i>Transportation sector</i> : Journeys are quicker and more predictable. Charges have been passed on to customers. Among couriers and delivery services, 25% support, 50% are neutral, 25% do not support the CC. Among logistics firms: 50% support, 25% are neutral, 25% do not support the CC. Restrictions on retail deliveries are a problem. <i>Convenience and food stores</i> : 60% do not support the CC, and 40% were neutral. Suppliers have reduced delivery frequency and imposed surcharges. Smaller businesses suffer more than larger businesses.
Freight Transport Association (FTA)	London Congestion charging: One year on	2004	Survey of members resulting in 167 responses	90% of freight operators responding were not able to make more deliveries; 69% mentioned that journey times remained unchanged within the CC zone.
Quddus et al. (2007)	The impact of the congestion charge on the retail business in London: An econometric analysis	2007	Data from a single large retail store with several branches to isolate impact of congestion charging on store located inside CC zone	Fall in weekly sales due to CC at John Lewis store located inside congestion charging zone is 5.5% and 8.2% depending on the model considered, and accounting for other economic effects cited by TfL (2006, 2007) such as decrease in tourism, a slow economy, the Iraq war, and closure of the main transit line serving the zone—the Central Line.

Figure 2. Distribution of respondents in the sample by size and sector of firm

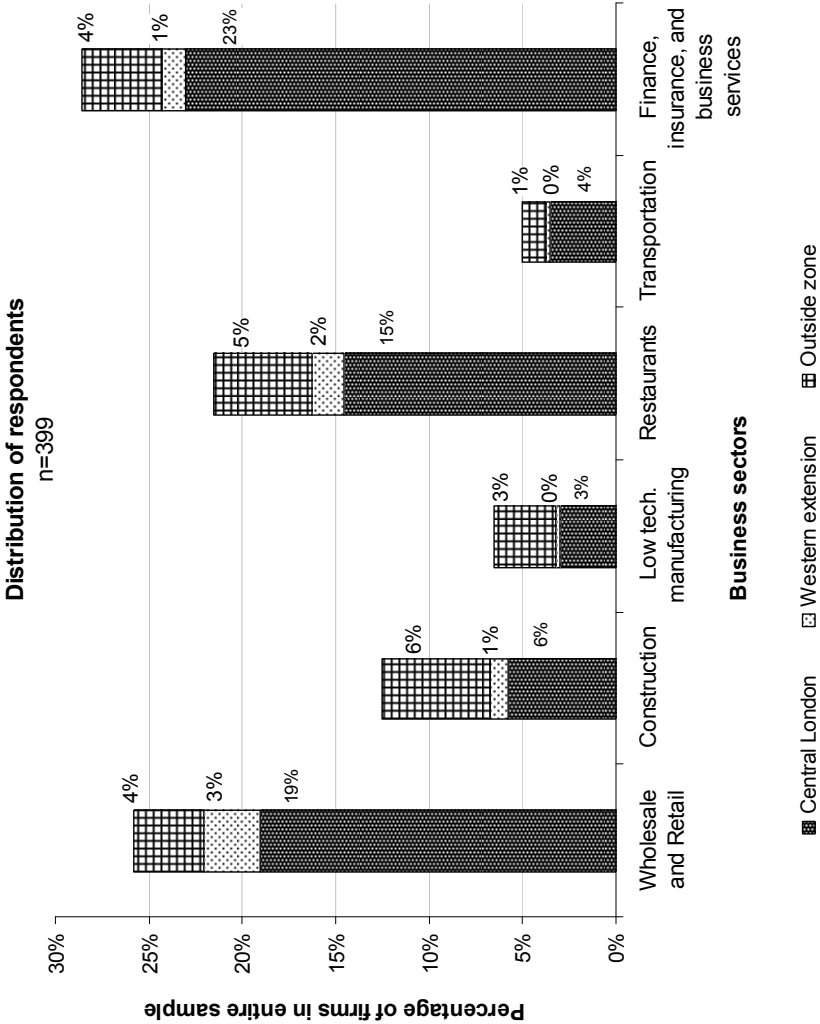
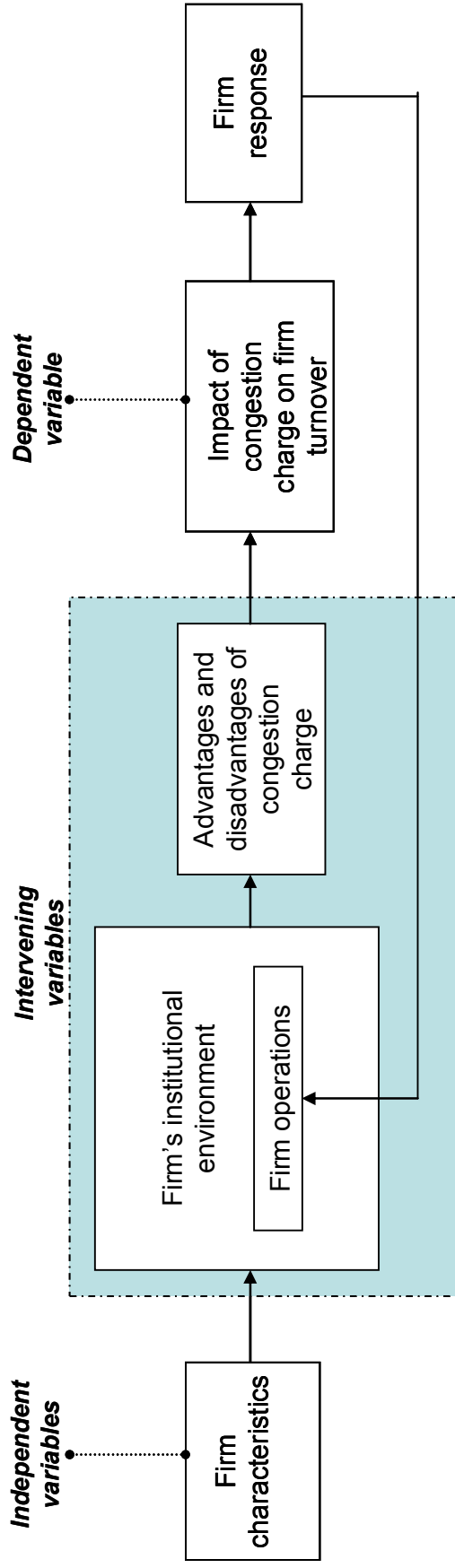


Figure 3. Causal Framework of Relationships Explored in the Survey

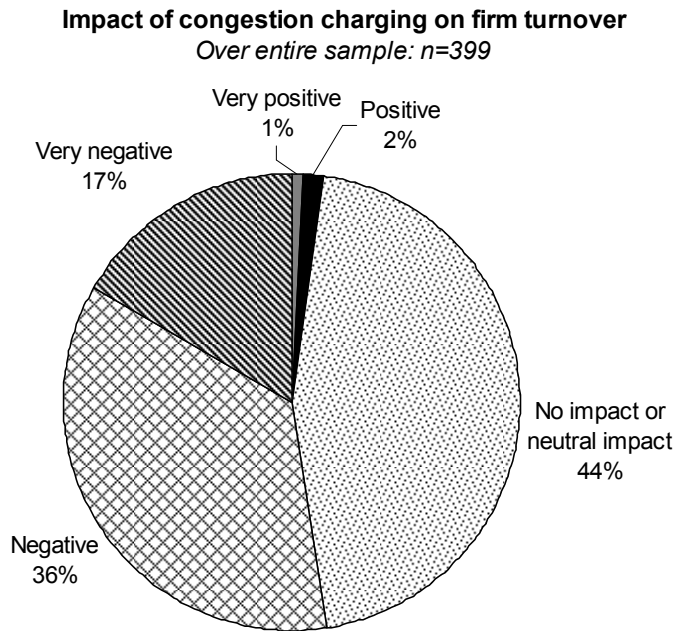


### KEY SURVEY VARIABLES

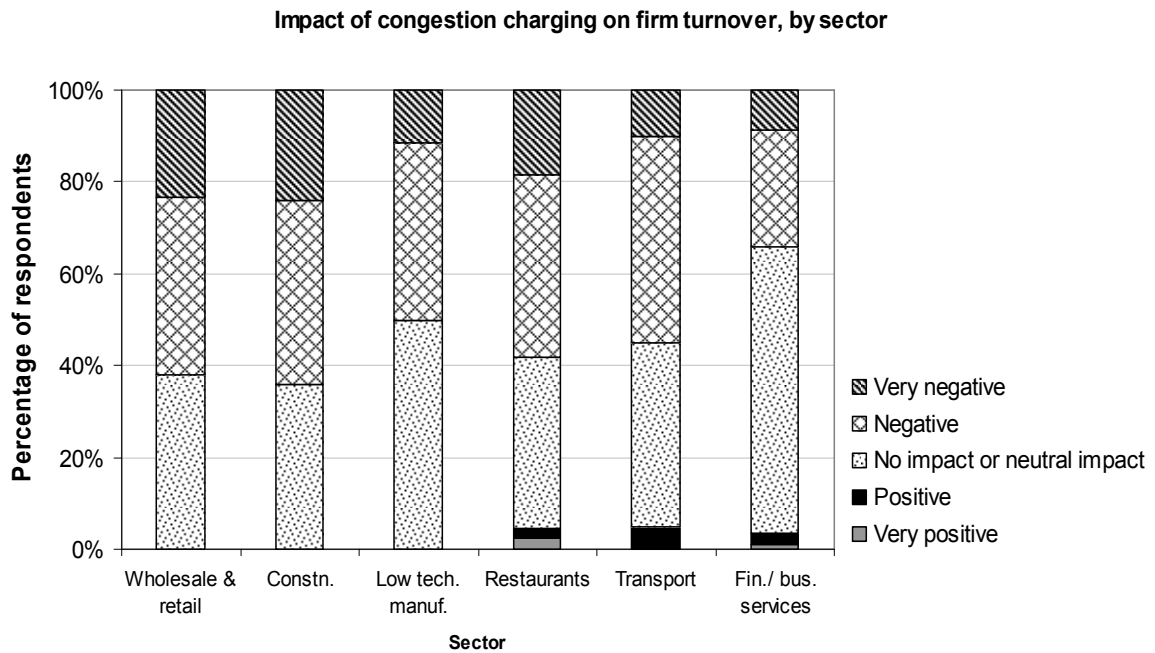
Characteristics	Institutional	Operational	Advantages/ Disadvantages	Impact on turnover	Responses
<ul style="list-style-type: none"> <li>■ Firm size measured in number of employees</li> <li>■ Annual sales in GBP from business databases</li> <li>■ Number of locations in London</li> <li>■ Geographic scope of the majority of operations</li> <li>■ Economic sector</li> <li>■ Firm's main product or service</li> <li>■ Location of firm</li> <li>■ Number of locations in the congestion charging zone</li> <li>■ Annual expenditure on road transport in GBP</li> </ul>	<ul style="list-style-type: none"> <li>■ Relative level of supply and demand in market</li> <li>■ Market competition</li> <li>■ Constraints of congestion charging compared with other local regulations</li> <li>■ Level of specialization of transport requirements</li> <li>■ Transport arrangement: own transport, hire by customer/supplier</li> <li>■ Incidence of charge: who pays for the congestion charge in the firm's operations?</li> </ul>	<ul style="list-style-type: none"> <li>■ Number of vehicles owned</li> <li>■ Time period of goods supply and delivery</li> <li>■ No. of shipments received from suppliers per week</li> <li>■ No. of shipments delivered to customers per week</li> <li>■ Location of majority of suppliers</li> <li>■ Location of majority of customers</li> <li>■ Percentage of employees using a car to commute</li> </ul>	<ul style="list-style-type: none"> <li>■ % change in transport costs due to congestion charge</li> <li>■ Staff turnover as a result of the congestion charge</li> <li>■ Burdens or disadvantages a result of the congestion charge (several options provided)</li> </ul>	<ul style="list-style-type: none"> <li>■ Ordinal variable measured as:                             <ul style="list-style-type: none"> <li>- Very positive</li> <li>- Positive</li> <li>- No impact or neutral impact</li> <li>- Negative</li> <li>- Very negative</li> </ul> </li> <li>■ Survey objective is to explain why some firms are more likely to experience negative impacts from congestion charging</li> </ul>	<ul style="list-style-type: none"> <li>■ Decisions in response to the congestion charge                             <ul style="list-style-type: none"> <li>- Changed suppliers</li> <li>- Changed location</li> <li>- Reduced business with customers in zone</li> <li>- Increased efficiency of transport operations</li> <li>- Changed vehicle type</li> <li>- Changed transport company</li> <li>- Contracted out more transport operations</li> <li>- Brought transport operations in-house</li> </ul> </li> </ul>



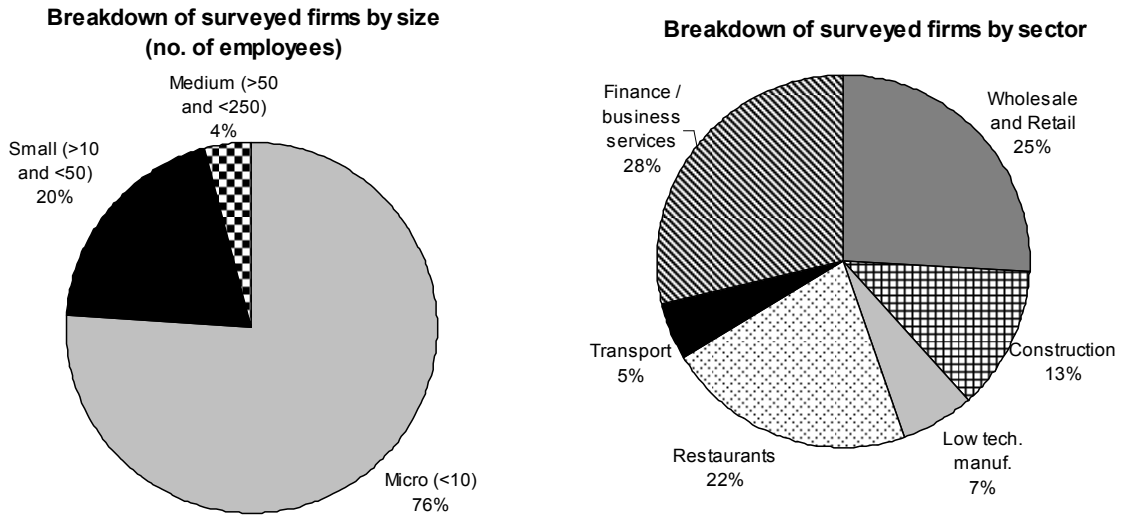
**Figure 4. Distribution of Dependent Variable in the Entire Sample**



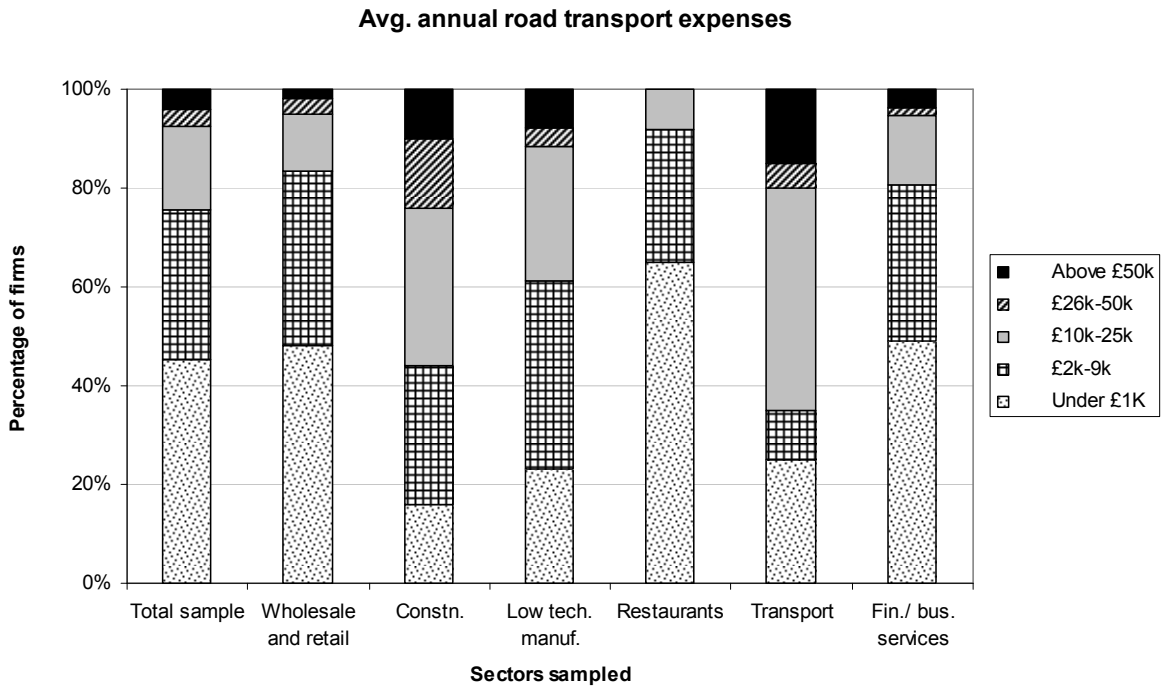
**Figure 5. Distribution of Dependent Variable by Sector of Surveyed Firm**



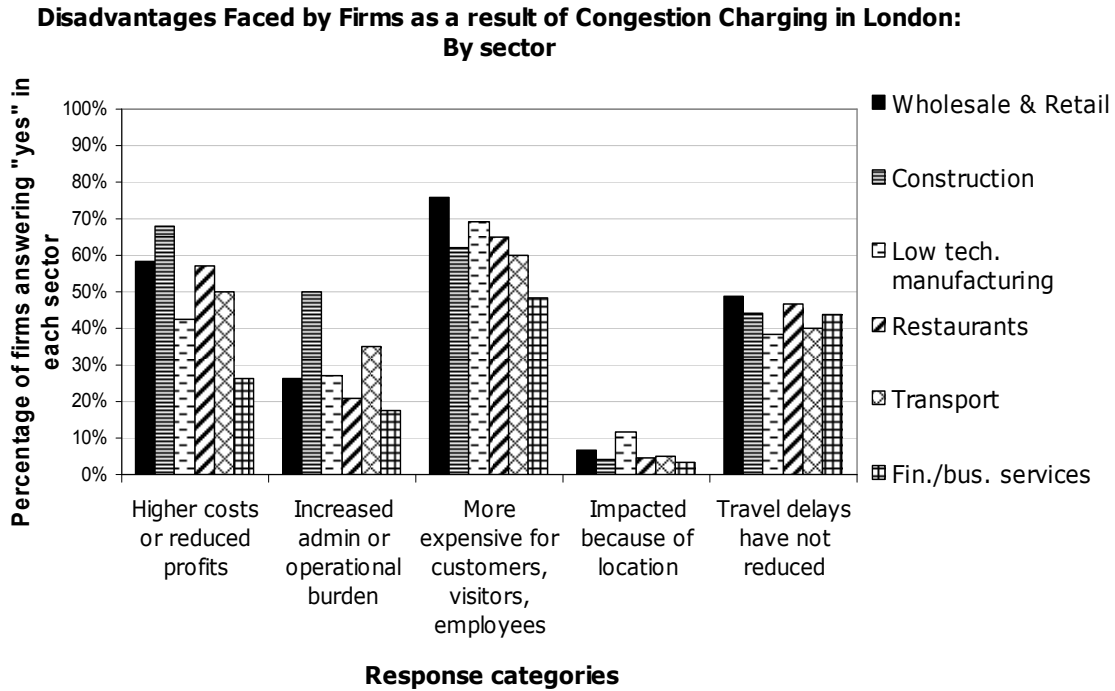
**Figure 6. Distribution of Surveyed Firms in the Sample by Size and Sector**



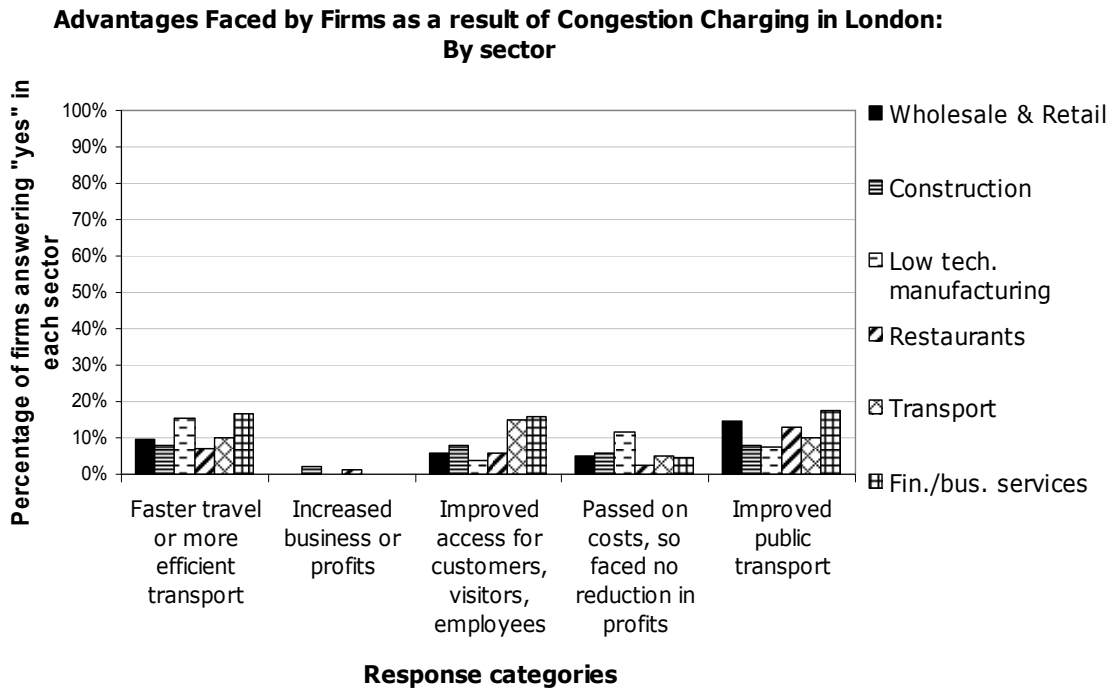
**Figure 7. Average Annual Road Transportation Expenditures by Sector**



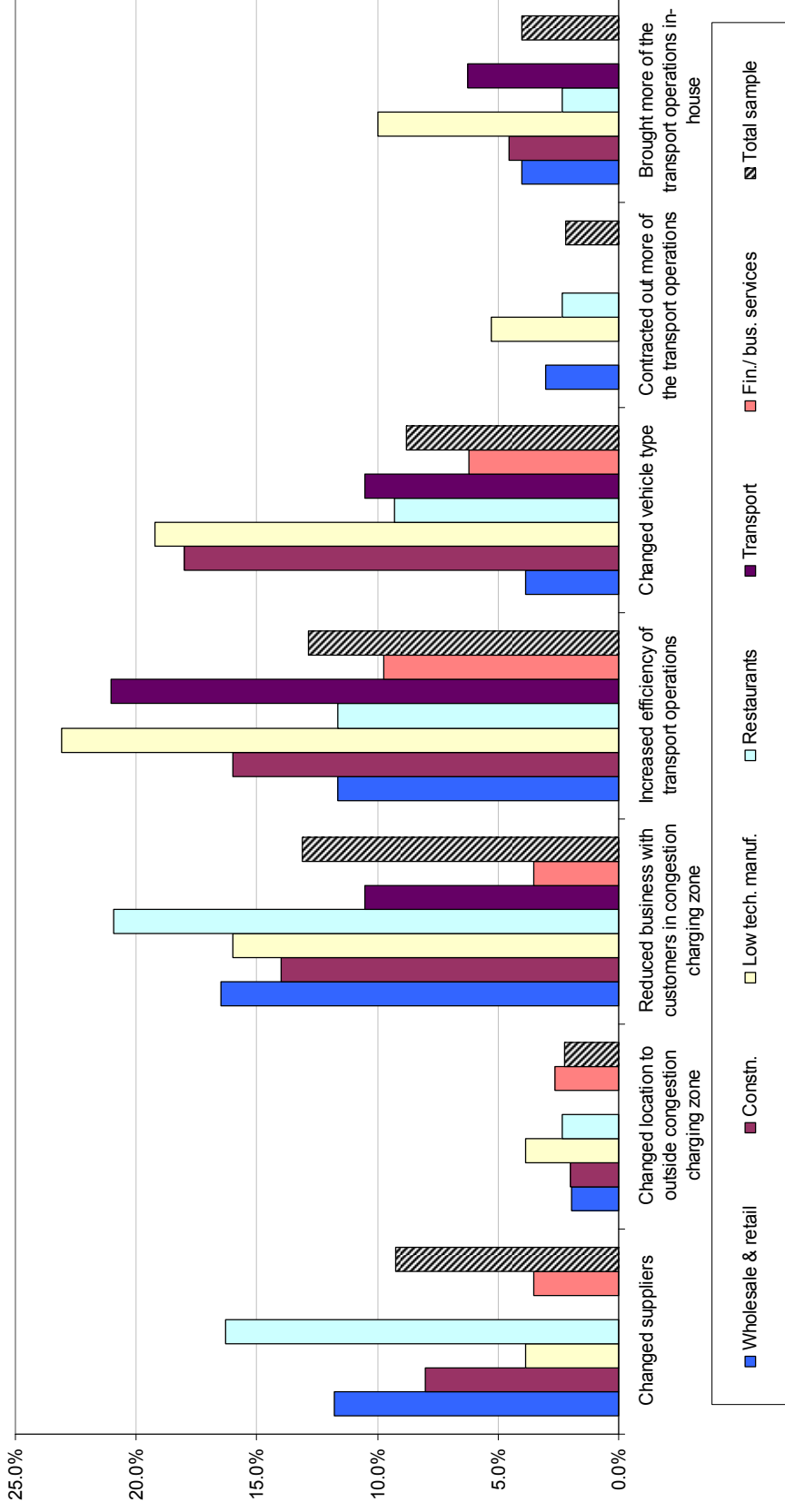
**Figure 8. Reported Advantages of Congestion Charging by Sector**



**Figure 9. Reported Disadvantages of Congestion Charging by Sector**



**Figure 10: Responses of firms to the London Congestion Charge by Sector (Decisions “already taken”)**



**Table 2. Ordinal Logistic Regression of probability of negative impacts due to congestion charging in London**

<b>Independent variables</b>	<b>Coeff.</b>	<b>Robust std. error</b>	<b>Prob. (p&gt; z )</b>	<b>z</b>	<b>Odds ratio</b>	<b>% change in odds</b>
<b><i>Firm characteristics</i></b>						
Total annual sales in GBP (millions)	-0.21	0.09	0.05	-1.97	0.81	-18.70
Scope of business <sup>a</sup>						
International vs. local	-0.82	0.26	0.16	-1.39	0.44	-55.90
National vs. local	-1.78	0.09	0.00	-3.16	0.17	-83.20
Location <sup>a</sup>						
Central London CC zone vs. outside zone						
Western ext. of CC zone vs. outside zone	1.99	3.03	0.00	4.80	7.30	630.40
	1.76	3.37	0.00	3.05	5.84	483.60
No. of locations in CC zone (squared)	0.00	0.00	0.05	-2.00	1.00	-0.20
Avg. road transport expenses/ year	0.34	0.16	0.00	2.95	1.41	41.00
Sector <sup>x</sup>						
Wholesale & retail	2.35	9.57	0.01	2.58	10.51	951.10
Construction	2.22	8.51	0.02	2.42	9.25	824.60
Restaurants	2.00	6.91	0.03	2.15	7.41	640.80
Low tech. manufacturing	2.83	16.90	0.01	2.83	16.89	1589.30
Services <sup>+</sup>	1.91	7.69	0.09	1.67	6.74	574.10
<b><i>Institutional and operational variables</i></b>						
Market conditions <sup>a</sup>						
Demand = supply vs. supply> demand	-0.78	0.19	0.06	-1.92	0.46	-54.40
Demand > supply vs. supply> demand	0.83	1.26	0.14	1.50	2.29	128.60
Constraints of congestion charge, compared to other local regulations (higher value implies more significant constraints) <sup>b</sup>	0.65	0.33	0.00	3.82	1.92	92.00
Specialization of transport requirements (higher value implies higher specialization) <sup>c</sup>	0.52	0.37	0.02	2.30	1.67	67.50
Transport arrangement						
Own vehicles and transport	0.25	0.48	0.51	0.66	1.28	28.10
Hired firm <sup>d</sup>	0.35	0.55	0.37	0.90	1.42	41.90
Provided by customer or supplier	0.79	0.83	0.04	2.09	2.20	119.70
Incidence of congestion charge costs <sup>a</sup>						
Customer pays	0.73	0.82	0.07	1.83	2.07	106.80
Supplier pays	-0.21	0.37	0.65	-0.46	0.81	-18.80
Firm itself pays	0.77	0.94	0.08	1.77	2.16	116.40
Transport firm pays	-2.78	0.06	0.00	-3.12	0.06	-93.80
Charge doesn't apply	0.45	0.92	0.44	0.77	1.57	56.60
% employees commuting to work by car	0.21	0.11	0.02	2.30	1.23	23.50
<b><i>Advantages and disadvantages</i></b>						
<b><i>Disadvantages</i></b> <sup>a</sup>						
Additional labor to obtain or deliver goods	1.93	5.17	0.01	2.59	6.92	591.70
More expensive for customers/employees	0.97	0.97	0.01	2.63	2.64	163.80
Higher transport costs	1.33	1.32	0.00	3.82	3.79	279.30
Higher staff turnover	1.65	1.47	0.00	5.85	5.22	421.60
Congestion has not reduced	0.59	0.52	0.04	2.05	1.81	80.50

*Advantages*

Passed on costs, so no impact	-1.61	0.12	0.01	-2.65	0.20	-80.00
Increased business or profits	-1.73	0.16	0.06	-1.92	0.18	-82.30

Log-likelihood of full model	-170.491	Likelihood Ratio	237.021
Pseudo $R^2$ (McFadden's R-squared)	0.41	Degrees of freedom	32
Number of observations	274	Model p-value	0.000

- b = raw coefficient
- z = z-score for test of b=0
- P>z = p-value for z-test
- Odds ratio = factor change in odds of Y for a unit increase in X
- % change in odds = percent change in odds of Y for unit increase in X

*Notes:*

Results in grey are not significant at the 90% confidence level

+ Services includes finance, insurance, real estate, business, and professional services sectors

x Reference category is the transportation sector.

a: Value is 1 if "yes" and 0 if "no". Coefficients are for "yes" vs. "no" responses.

b: Values are 1: Very insignificant; 2: Fairly insignificant; 3: Not significant, not insignificant; 4: Fairly significant; and 5: Very significant

c: Values are 1: Not at all specialized; 2: Fairly specialized; and 3: Very specialized

d: Values are 1: Very positive; 2: Fairly positive; 3: Neutral; 4: Fairly negative; and 5: Very negative

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## Concluding Discussion

In the three papers that constitute this dissertation, I investigate different applications of road pricing policies in multiple geographic contexts, highlighting the gaps in current knowledge about the impacts of such policies.

The first paper is clearly distinct from the other two in its focus on passenger transport and in approaching congestion pricing as a solution in developing countries. With regard to travel demand management, the Latin American cities that I studied are unique in that they already have driving restrictions in effect, but traffic congestion and air pollution continue to increase. It is therefore becoming necessary to consider more radical approaches to deal with these external costs of increasing motorization. The paper indicates the importance of (a) public awareness regarding the true costs of driving, (b) availability of safe and reliable alternatives to the use of private vehicles and implementation of measures that complement the objectives of road pricing, and (c) the systematic collection of data and analysis of alternative policies to manage travel demand. The issue of equity is found to be less relevant in these cities, given that cars are typically owned and used by people with higher incomes. Still, the implementation of congestion pricing must be considered in tandem with the above conditions for the policy to receive public support. While the issues discussed in this paper are common across several cities in the developing world, other cities that may consider implementation of congestion pricing will not typically have vehicle restrictions already in place. This makes the four cases considered in the first paper more comparable to each other than to other developing cities in the world.

Ideas such as road pricing will remain radical and will draw opposition as long as there are insufficient alternatives to the use of private vehicles. This is the case in several cities and regions around the world, particularly in developing countries where the ownership and use of private vehicles is directly linked with income growth, and in regions characterized by sprawled land use development. Therefore, it is often recommended that road pricing be implemented as a package of measures aiming to control the use of private vehicles, to promote public and non-motorized transport, to set parking charges according to the real value of land particularly in congested locations, and to make complementary urban improvements. The institutional changes required to make road pricing an acceptable idea are complex, and can only begin with

extensive public information and education about the often unrecognized externalities of the growing use of private vehicles.

The first paper presents an exploratory study and there is much scope to build on this work through comparative analyses of the economic impacts of vehicle restrictions and possible congestion pricing schemes for the four cities. The relative merits and demerits of different policy proposals must be identified with quantification of the costs and benefits to various sections of the population. The work presented in this paper can also be extended by conducting representative surveys to understand the views of the general public about the problem of congestion, the effectiveness of the vehicle restrictions, and the policy of congestion pricing in each of the four cities.

The second paper explores the institutional factors that could result in varying impacts of road pricing on firms in different sectors as a result of the potential distance-based pricing policy proposed in the Netherlands. Distance-based road pricing at a nation-wide level is also under consideration in the United Kingdom where an ex-ante analysis of potential business impacts similar to that presented in this paper would be useful. Such a sectoral analysis can enhance the findings from aggregate freight transport models that are typically used to model the economic impacts of road pricing. Since road pricing is essentially an economic instrument, assessment of impacts by business sector is essential to understand how the regional economy is likely to be affected. Freight transportation contributes to the economy, and businesses are affected differently according to their size, sector, product type, and the manner in which they organize the production and distribution of their goods. Equity issues are not only to be considered with respect to passenger transport but also with respect to specific types of businesses that must be identified.

The key business sectors will be different in different regions, but analysis must take the entire supply chain of goods into account to identify the businesses most likely to bear the incidence of the costs of road pricing and those that are most likely to benefit. The operations, market environment, and economic power of firms in their supply chains are all important determinants of how firms might be impacted by road pricing. Additionally, the types of impacts will differ not only by the type of business sector but also by the features of the road pricing policy that is implemented. Although I use the proposed policy in the Netherlands as a case, the conceptual framework presented in this study can be usefully applied to other contexts and

business sectors as well. Despite the relatively small sample size of 21 in-depth interviews, the conceptual framework was formulated from themes and relationships among variables that were repeatedly mentioned by respondents independently of each other. I therefore believe that it captures the important issues with regard to the potential impacts of road pricing on businesses and freight transportation. Further research using a larger sample size and including other sectors such as the finance and business services sectors in the Netherlands, would add considerable value to the work presented here.

Distance-based road pricing, as proposed in the Netherlands, is possibly the most sophisticated form of road pricing that has been recently proposed, and is closest to marginal social cost pricing. However, the fact that the Dutch road pricing policy will reduce other vehicle taxes for road users may produce only a mild change in travel behavior. This emphasizes the divergence between the goals of public acceptability, political feasibility, and the need to effectively manage the externalities of transportation.

The third paper presents a part of the survey data that I collected in London based on the conceptual framework proposed in the second paper. The study focuses on identifying and validating the relationships between the variables in the conceptual framework. I obtained useful information about how businesses across several sectors have responded to the London congestion charge in terms of adapting their operations, making location changes, dealing with the increased costs in their supply chains, and realizing gains either due to travel time savings or due to positions of power in their business relationships. The analysis is based on stated preference data, which has certain limitations as discussed in the conclusions of the paper. However, with revealed preference data, as used by Transport for London, it is difficult for a researcher to isolate the impacts of the congestion charge measured by a firm's business indicators from the impacts of other economic phenomena, particularly when disaggregated data are not available. I preferred to use a stated preference approach so that respondents responsible for operational decision-making could be asked to identify the specific effects of the congestion charge and operational changes they had made in response to it.

My objective was to understand what types of firms were more or less positively or negatively impacted by the London congestion charge and why. Other empirical studies were available for some of the sectors so that the findings could be compared. However, at least two of the six sectors, namely construction and manufacturing (including the manufacturing of food

products, apparel, furniture, and published media), considered in this paper, have not been studied before. Construction and food manufacturing are sectors with relatively high transportation intensity that require reliable freight transportation. The other sectors included in his research, namely wholesale and retail, finance, insurance, and business services, restaurants, and transportation, are more widely found in metropolitan areas and firms in these sectors have similar types of operations. The institutional environment of market conditions and regulations would of course differ in different contexts. However, the paper offers guidance on the research questions that must be asked and the disaggregated analysis that must be done when considering the implementation of location-based congestion pricing similar to the London model in other cities. It also indicates the limitation of this particular policy design when compared with other more dynamic forms of road pricing. In further research, efforts must be made to compare the findings from this survey to detailed revealed preference data for firms that provide the necessary information about their sales and costs.

Location-based charges or city center access charges can affect the location decisions of people and businesses and their decisions to travel to the charged location. Some issues such as effects on property prices were not discussed in this dissertation, but there is anecdotal evidence from London showing variations in property prices as a result of the congestion charge. The findings from London show that location-based charges that are in effect all day, while being administratively simpler to implement, may create disadvantages for certain economic sectors important in urban centers such as retail, distribution, and some types of business services.

Governments must monitor and work with businesses to ensure that any gains in travel time and productivity from road pricing policies lead to the expected economic benefits. For this, policy-makers must have a better understanding of how supply chains in various sectors operate and about the incidence of the benefits and costs of road pricing on firms in a supply chain. Accordingly, a framework of incentives and disincentives can be designed so that particular types of firms are not disadvantaged in all situations. For example, the findings from London showed that small retailers suffer in two ways from a location-based congestion charge. On the supply side, suppliers impose surcharges or reduce the frequency of their deliveries into the congestion charging zone, and on the demand side, businesses and customers from outside the zone reduce their patronage of establishments located inside the zone.

From a theoretical microeconomic perspective, if there are external costs that result from the use of roads by private and commercial vehicles, then road users must pay a charge that approximates the marginal social costs of their travel if those costs are to be internalized. However, for road pricing to be politically acceptable, the message that is generally publicized is that road users would pay a charge for a higher level of service; for example, former Mayor Ken Livingstone implemented the congestion charge in London as part of a manifesto of actions to “get London moving”, i.e., to reduce traffic congestion. If there are institutional factors because of which all road users do not have the same opportunities and alternatives for travel time savings available to them, despite paying the charge, then road pricing will not find widespread public support. For passengers, incentives in the form of improvements to the public transport network and discounts for the use of public transport can be provided. However, fewer alternatives are possible for freight transport and the other transportation needs of businesses.

Freight travel demand appears to be comparatively less sensitive to transportation costs than passenger travel demand. Arguably, if this is the case, freight transport should benefit from the reduced congestion and gains in travel time that can be realized by a larger proportion of passengers choosing other travel options. But it appears that these gains are not being realized by all businesses in the case of London. Certain types of businesses are more likely to face negative impacts, and in sectors such as transportation, where businesses may face positive impacts, the gains are not transferred to customer firms in the form of reduced prices. Therefore, the vocal opposition of businesses will remain an obstacle unless certain policy actions are considered. These could include, for example, incentives for the receivers of goods to accept deliveries in hours outside the congestion charging window, applying the congestion charge in all locations but varying it by time of day, and ensuring that any changes in the value of the charge are based transparently and dynamically on the level of congestion, pollution, and other externalities. In the absence of such measures, the institutional factors that affect the operations of most firms will make it difficult for them to realize the gains from road pricing.

It is evident from the research presented in this dissertation that there are sections of the population, and sectors and types of businesses that will be disadvantaged by the implementation of road pricing policies. Detailed disaggregated analyses by population group and business sector must be conducted to determine the types of incentives that can be considered. In the case of businesses, the vast majority of firms are small in size and can potentially face negative spillover effects of road pricing. These effects cannot be ignored,

especially when road pricing is implemented in the form of a location-based charge as in London.

In view of the growing attention to road pricing in cities and regions around the world, the institutional issues discussed in these papers are highly relevant. Although the sample sizes for the interviews and surveys used in each of the three papers were limited due to resource constraints, the findings provide useful direction to policy-making. Further empirical research is important to extend and test the conclusions of each paper.



## APPENDIX

### Section I. Sector list with UK SIC code (2003) category in parentheses

**1) Low technology manufacturing:** Based on the report for the Greater London Authority by Prothero (2007), the manufacturing sectors most relevant for London in terms of employee jobs are the following.

- Publishing and Printing: 22
- Food products and beverages: 15
- Furniture and miscellaneous goods: 36
- Fabricated metal products: 28
- Apparel: 18
- Textiles: 17
- Rubber and plastic goods: 25
- Wood and paper products: 20 and 21

#### **2) Construction**

All codes beginning with 45

#### **3) Wholesale and Retail**

- Wholesale businesses: 51.1 through 51.9
- Retail businesses: 52.1 through 52.7

A variety of retail is covered in the final sample, such as food stores, clothing stores, and consumer goods stores.

#### **4) Restaurants**

- Restaurants, takeaway shops, and cafes: 55.3
- Bars and clubs: 55.4
- Canteens and caterers: 55.5

Codes beginning with 55.1 (hotels) were excluded because they are not likely to be small and medium enterprises.

#### **5) Transportation services**

- Freight transport and courier services: Only includes codes beginning with 60.24, 63.1, 63.4, and 64.12. These specifically represent freight transport and supporting services such as warehousing, haulage services, freight forwarding, and private courier services.

Codes beginning with 60.21, 60.22, and 60.23 were excluded because they were less relevant to the research questions. For example, 60.22 (taxi operation) is not important for this research because taxis are exempt from the congestion charge.

#### **6) Finance, Insurance, and Business Services**

Banking and insurance: All codes beginning with 65 and 66  
The following codes all come under Business Services.

- 74.1- 74.3: Financial, management, legal and accounting services, architectural, engineering and analytical services
- 74.7: Cleaning services – important because they need to travel with equipment
- 74.8: All other types of business services – important because they often function like retail

## SECTION II: Distribution of Survey Variables by Sector

### Cells Show Percentage of firms in each Sector Unless Specified Otherwise

Independent Variables	Total sample	Wholesale and retail	Constrn.	Low tech. manuf.	Restaurants	Transport	Fin./ bus. services	Freq. sample	P-value for total sample
<b>Firm characteristics</b>	<b>n=399</b>	<b>n=103</b>	<b>n=50</b>	<b>n=26</b>	<b>n=86</b>	<b>n=20</b>	<b>n=114</b>		Associatio n with DV
Sector (% firms)	100.0	25.8	12.5	6.5	21.6	5.0	28.6	399	*
No. of employees (mean) <sup>+</sup>	10.4 (18.9)	5.1 (7.6)	19.9 (35.2)	9 (9.2)	10.8 (17.6)	13.9 (30.4)	10.4 (14.1)	398	n.s.
Annual turnover in GBP, 2007 (mean) <sup>+</sup>	787,163 (2,445,419)	984,121 (3,755,070)	1,362,309 (2,886,450)	1,303,396 (3,174,061)	219,047 (275,364)	561,311 (615,787)	700,581 (1,229,445)	390	n.s.
No. of locations in London (mean) <sup>+</sup>	1.8 (6.1)	1.4 (1.8)	3.6 (15.9)	1.1 (0.4)	2.2 (4.7)	1.4 (2.1)	1.1 (0.7)	398	n.s.
No. of locations in CC zone (mean) <sup>+</sup>	1.2 (2.5)	1.1 (1.1)	1.7 (4.3)	0.8 (0.9)	1.7 (4.0)	1.2 (1.7)	1.0 (0.5)	398	n.s.
Scope of business (% firms)									
Local	68.2	68.9	84.0	50.0	95.3	60.0	45.6	272	**
National	17.5	18.5	10.0	30.8	3.5	15.0	28.1	70	**
International	14.3	12.6	6.0	19.2	1.2	25.0	26.3	57	**
Location in London (% firms)									
Central London	68.9	73.8	46.0	46.1	67.4	70.0	80.7	275	n.s.
Western ext.	7.5	11.6	8.0	3.9	8.2	5.0	4.4	30	n.s.
Outside zone	23.6	14.6	46.0	50.0	24.4	25.0	14.9	94	n.s.
Avg. annual road transport expenses (% firms)									**
Under £1K	45	48.0	16.0	23.0	65.1	25.0	49.1	180	
£2k-9k	30	35.3	28.0	38.4	26.8	10.0	31.5	121	
£10k-25k	17	11.8	32.0	26.9	8.1	45.0	14.0	67	
£26k-50k	4	2.9	14.0	3.9	0.0	5.0	1.8	14	
Above £50k	4	2.0	10.0	7.8	0.0	15.0	3.6	16	

Note: For nominal/ordinal variables, column percentages of different categories of each variable equal 100%

+ Standard errors in parentheses for ratio-scale variables

n.s.: Test of relationship with dependent variable not significant (p > 0.05)

\*\* p < 0.01 (association significant at 99% confidence level); \* p < 0.05 (association significant at 95% confidence level)

Independent Variables	Total sample n=399	Wholesale and retail n=103	Constn. n=50	Low tech. manuf. n=26	Restaurants n=86	Transport n=20	Fin./ bus. services n=114	Freq.	P-value for total sample Association with DV
<i>Cells below report percentage of respondents</i>									
Market conditions									
Supply>Demand	19.5	21.9	17.6	16.0	29.1	23.8	10.6	77	**
Demand>Supply	10.2	11.4	11.8	8.0	9.3	14.3	8.9	41	*
Supply=Demand	70.3	66.7	70.6	76.0	61.6	61.9	80.5	278	**
High local competition									
No	35.3	51.4	38.0	27.0	10.5	9.5	44.7	140	*
Yes	64.7	48.6	62.0	73.0	89.5	90.5	55.3	257	
Constraints of CC									
Very significant	19.1	25.7	17.7	19.2	18.6	19.1	13.9	76	**
Fairly significant	25.2	23.8	25.5	27.0	27.9	14.3	26.1	100	
Neither	31.2	29.5	29.4	15.4	40.7	33.3	29.6	126	
Fairly insignificant	16.1	16.2	13.7	19.2	7.0	33.3	20.0	63	
Very insignificant	8.4	4.8	13.7	19.2	5.8	0.0	10.4	34	
Transport specialization									
Not at all specialized	61.6	65.7	59.1	60	58.8	47.4	81.8	170	*
Fairly specialized	26.7	20.6	36.4	20.0	30.6	42.1	0.0	74	
Very specialized	11.7	13.7	4.5	20	10.6	10.5	18.2	33	
Transport arrangement									
Own	48.3	38.1	84.3	61.5	37.2	90.5	39.1	192	**
Hire transport firm	16.8	35.2	21.6	26.9	9.3	19.1	0.9	65	*
Customer/supplier	41.1	57.1	35.3	38.5	74.4	23.8	7.8	164	n.s.
Incidence of CC costs									
Customer	34.6	33.3	41.2	30.8	24.4	57.1	37.4	138	*
Supplier	15.1	17.1	3.9	23.1	36.1	14.3	0.9	60	n.s.
Firm itself	56.7	58.1	56.9	53.9	54.7	42.9	60	225	**
Transport firm	1.7	4.8	0	3.9	1.2	0	0	7	n.s.
CC costs N/A	9.4	12.4	5.9	7.7	13.9	9.5	5.2	38	**

Note: Column percentages of different categories of each variable equal 100%

n.s.: Test of relationship with dependent variable not significant (p > 0.05)

\*\* p < 0.01 (association significant at 99% confidence level); \* p < 0.05 (association significant at 95% confidence level)

Independent Variables	Total sample	Wholesale and retail	Constn.	Low tech. manuf.	Restaurants	Transport	Fin./ bus. services	Freq.	P-value for total sample
<b>Operational variables</b>	<b>n=399</b>	<b>n=103</b>	<b>n=50</b>	<b>n=26</b>	<b>n=86</b>	<b>n=20</b>	<b>n=114</b>		Associa tion with DV
Vehicles owned (mean)	2.4 (9.7)	0.9 (2.2)	7.8 (20.4)	2.7 (3.4)	0.8 (1.2)	10.6 (25.5)	0.9 (1.6)	396	n.s.
Time period for majority of supplies and deliveries									
Before 7am	7.2	6	11.4	10.5	7.1	0	9.1	20	
Between 7am and 6pm	91.7	92.0	88.6	89.5	91.7	100.0	90.9	254	n.s.
After 6pm	1.1	2.0	0.0	0.0	1.2	0.0	0.0	3	
Shipments received/week									
None	10.1	10.0	4.6	15.0	4.7	27.8	36.4	28	n.s.
1 to 5	49.3	52.0	36.4	45.0	52.9	55.6	45.4	137	
6 to 10	19.0	19.0	31.8	15.0	17.7	0.0	18.2	53	
11 to 20	12.9	12.0	13.6	15.0	15.3	11.1	0.0	36	
21 to 50	7.2	6.0	13.6	5.0	7.1	5.6	0.0	20	
51 to 100	1.1	1.0	0.0	0.0	2.3	0.0	0.0	3	
More than 100	0.4	0.0	0.0	5.0	0.0	0.0	0.0	1	
Shipments delivered/week									
None	37.3	25.5	11.4	15.0	70.6	22.2	54.6	103	**
1 to 5	27.9	39.8	15.9	30.0	18.8	22.2	45.4	77	
6 to 10	8.7	11.2	22.7	10.0	0.0	5.6	0.0	24	
11 to 20	9.8	8.2	18.2	25.0	2.4	22.2	0.0	27	
21 to 50	9.8	8.2	25.0	10.0	3.5	16.7	0.0	27	
51 to 100	2.5	1.0	4.5	5.0	3.5	0.0	0.0	7	
More than 100	4.0	6.1	2.3	5.0	1.2	11.1	0.0	11	
Location of majority of suppliers									
Inside CC zone	21.6	16.0	20.5	25.0	21.2	38.9	45.4	60	n.s.
Outside CC zone; in London	44.2	35.0	47.7	30.0	57.6	44.4	36.4	123	n.s.
Outside London	34.2	49.0	31.8	45.0	21.2	16.7	18.2	95	n.s.
Location of majority of customers									
Inside CC zone	44.6	42.2	48.0	26.9	65.1	30.0	36.3	177	**
Outside CC zone; in London	28.7	29.4	30.0	38.5	23.3	35.0	28.3	114	n.s.

	26.7	28.4	22.0	34.6	11.6	35.0	35.4	106	**
Outside London	26.7	28.4	22.0	34.6	11.6	35.0	35.4	106	**
% employees using cars to commute									
None	44.1	51.5	24.0	19.2	55.8	15.0	48.2	176	**
Less than 10%	22.3	23.3	18.0	30.8	19.8	10.0	25.4	89	
10-25%	7.0	5.8	4.0	7.7	8.1	10.0	7.9	28	
26-50%	9.8	7.8	12.0	7.7	4.7	25.0	12.3	39	
51-75%	3.8	2.9	6.0	15.4	3.5	0.0	1.8	15	
More than 75%	13.0	8.7	36.0	19.2	8.1	40.0	4.4	52	

Independent variables	Total sample	Wholesale and retail	Constn.	Low tech. manuf.	Restaurants	Transport	Fin./ bus. services	Freq.	P-value over total sample
<b>Advantages and Disadvantages</b>	n=399	n=103	n=50	n=26	n=86	n=20	n=114	Association with DV	
Change in transport costs due to CC									
Increased by >40%	6.5	5.8	4	7.7	5.8	10.0	7.9	26	**
Increased by 26-40%	2.0	2	0	3.9	2.3	0	2.6	8	
Increased by 11-25%	17.0	22.3	26	23.1	11.6	10.0	12.3	68	
Increased by 0-10%	27.3	32	28	26.9	26.8	30.0	22.8	109	
No change	44.9	35.9	42	34.6	48.8	45.0	53.5	179	
Decreased by 0-10%	1.8	2	0	3.8	2.3	5.0	0.9	7	
Decreased by 11-25%	0.3	0	0	0	1.2	0	0	1	
Decreased by 26-40%	0	0	0	0	0	0	0	0	
Decreased by >40%	0.3	0	0	0	1.2	0	0	1	
Reduced staff numbers (yes) <sup>a</sup>	14.0	17.5	14.0	0.0	18.6	15.0	10.5	399	**
Had high staff turnover (yes) <sup>a</sup>	15.5	15.5	8.0	7.7	17.4	35.0	15.8	399	**
<b>Disadvantages<sup>a</sup></b>									
Higher costs/reduced profits	48.6	58.3	68.0	42.3	57.0	50.0	26.3	399	**
Increased admin or operational burden	26.1	26.2	50.0	26.9	20.9	35.0	17.5	399	**
More expensive for customers, visitors, employees	62.7	75.7	62.0	69.2	65.1	60.0	48.2	399	**
Impacted because of location	5.3	6.8	4.0	11.5	4.7	5.0	3.5	399	**
Delays have not reduced	45.1	48.5	44.0	38.5	46.5	40.0	43.9	399	**

<b>Advantages<sup>a</sup></b>										
<i>Faster travel or more efficient transport</i>	11.3	9.7	8.0	15.4	7.0	10.0	16.7	399	**	
<i>Increased business or profits</i>	0.5	0.0	2.0	0.0	1.2	0.0	0.0	399	n.s.	
<i>Improved access for customers, visitors, employees</i>	9.3	5.8	8.0	3.8	5.8	15.0	15.8	399	n.s.	
<i>Passed on costs, so faced no reduction in profits</i>	4.8	4.9	6.0	11.5	2.3	5.0	4.4	399	n.s.	
<i>Improved public transport</i>	13.5	14.6	8.0	7.7	12.8	10.0	17.5	399	**	

Note: Column percentages of different categories of each variable equal 100%

n.s.: Test of relationship with dependent variable not significant (p > 0.05)

\*\* p < 0.01 (association significant at 99% confidence level); \* p < 0.05 (association significant at 95% confidence level)

CC: Congestion Charging

a: Reference category is the "no" response not shown here – "yes"+ "no" responses total 100% for each sector

	Total sample	Wholesale and retail	Constn.	Low tech. manuf.	Restaurants	Transport	Fin./ bus. services	P-value for total sample	
								Freq.	Association with DV
<b>Attitudinal variables</b>	n=399	n=103	n=50	n=26	n=86	n=20	n=114		
In favor of CC before implementation?									
No	64.7	71.8	76.0	73.1	68.6	65.0	48.3	257	**
Yes	21.3	18.5	16.0	7.7	15.1	25.0	33.3	57	
Neutral	14.0	9.7	8.0	19.2	16.3	10.0	18.4	85	
Current attitude towards the congestion charge?									
Very positive	2.8	1.9	0.0	0.0	2.3	0.0	6.1	11	**
Fairly positive	10.3	4.9	2.0	7.7	10.5	15.0	18.5	40	
Neutral	21.5	19.4	12.0	15.4	30.2	10.0	24.6	86	
Fairly negative	28.3	28.2	36.0	46.1	22.1	30.0	25.4	114	
Very negative	37.1	45.6	50.0	30.8	34.9	45.0	25.4	148	

Note: Column percentages of different categories of each variable equal 100%

n.s.: Test of relationship with dependent variable not significant (p > 0.05)

\*\* p < 0.01 (association significant at 99% confidence level); \* p < 0.05 (association significant at 95% confidence level)

CC: Congestion Charging

### SECTION III: Addition of categories of variables to regression model

Dependent variable	(1)	(2)	(3)
<b>Negative impact of congestion charging (CC) on business turnover</b>	Firm Characteristics	Adding Institutional and Operational variables	Adding Advantages & Disadvantages
<b>Firm Characteristics</b>			
Total annual sales in GBP (millions)	-0.154***	-0.204***	-0.207**
Scope of business <sup>a</sup>			
International vs. local	-1.032***	-1.104**	-0.818
National vs. local	-0.828***	-1.605***	-1.784***
Location <sup>a</sup>			
Central London CC zone vs. outside zone	0.671***	1.488***	1.988***
Western ext. of CC zone vs. outside zone	0.598	1.204**	1.764***
No. of locations inside CC zone (squared)	-0.003***	-0.002*	-0.002**
Avg. road transport expenses per year	0.402***	0.337***	0.343***
Sector <sup>a</sup>			
Wholesale & retail	1.240**	1.793**	2.352***
Construction	0.900*	1.440**	2.224**
Restaurants	0.956*	1.457*	2.003**
Low tech. manufacturing	0.539	1.503*	2.774***
Services <sup>++</sup>	0.125	0.753	1.908*
Transportation <sup>+</sup> (reference category with negative coefficient)			
<b>Institutional and Operational variables</b>			
Market conditions <sup>a</sup>			
Demand = supply vs. supply > demand		-0.890**	-0.784*
Demand > supply vs. supply > demand		0.049	0.827
Constraints of congestion charge, compared to other local regulations (higher value implies more significant constraints) <sup>b</sup>		0.715***	0.652***
Specialization of transport requirements (higher value implies higher specialization) <sup>c</sup>		0.452**	0.516**
Transport arrangement <sup>a</sup>			
Own vehicles and transport		0.302	0.248
Hired firm <sup>d</sup>		0.871***	0.350
Provided by customer or supplier		0.729**	0.787**
Incidence of costs of congestion charge <sup>a</sup>			
Customer pays		0.762**	0.727*
Supplier pays		-0.266	-0.209
Firm itself pays		0.933**	0.772*
Transport firm pays		-3.801***	-2.784***
Charge doesn't apply		-0.170	0.448
Employees commuting to work by car		0.228***	0.211**
<b>Advantages and disadvantages of the CC</b>			
Disadvantages <sup>a</sup>			
Additional labor to obtain/ deliver goods			1.934***
More expensive for customers/employees			0.970***
Higher transport costs			1.333***
Higher staff turnover			1.652***
Congestion has not reduced			0.591**

Advantages <sup>a</sup>			
Passed on costs, so no impact			-1.608***
Increased business or profits			-1.731*
<i>Goodness-of-fit measures<sup>e</sup></i>			
Pseudo R-squared (McFadden's R-squared or likelihood-ratio index)	0.10	0.30	0.41
Log-likelihood of full model	-356.782	-202.536	-170.491
Wald chi2 test statistic	73.65	125.25	136.87
Degrees of freedom	12	25	32
Model p-value	0.000	0.000	0.000
Likelihood ratio	81.223	172.931	237.021

*Notes:*

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

+ Reference category is the Transportation sector. This dummy variable has a negative sign on the coefficient across all models, showing an opposite impact in comparison to the other sectors.

++ Services includes the finance, insurance, real estate, business, and professional services sectors

a: Value is 1 if response to option is 'yes' and 0 if "no". Coefficients are for "yes" vs. "no" responses.

b: Values are 1: Very insignificant; 2: Fairly insignificant; 3: Not significant, not insignificant; 4: Fairly significant; and 5: Very significant

c: Values are 1: Not at all specialized; 2: Fairly specialized; and 3: Very specialized

d: For firms in the services sector, this option included firms using taxis for their transport arrangements

e: Lower absolute value of Log-Likelihood statistics implies a better model fit.

Some of the transportation arrangement variables and those related to incidence of costs of the congestion charge (CC) lose statistical significance when the advantages and disadvantages are added – i.e. when moving from the 2<sup>nd</sup> to the 3<sup>rd</sup> model. This indicates that the transport arrangement and cost incidence variables may be correlated with the advantages and disadvantages of the CC. This is to be expected. Only the transport arrangement variables were not found to be jointly significant in the final model