CHAPTER 1

INTRODUCTION

"Natura deficit, fortuna mutatur, deus omnia cernit." (Marguerite Yourcenar, *Memoirs of Hadrian*)

"We shall require a substantially new manner of thinking if mankind is to survive." (Albert Einstein)

"National solutions ought to base themselves in local solutions, and only emerging from both is our contribution to international solutions conceived. If we do not attend to basic local problems, we will never gain true unmocking access to this most celebrated globality." (Carlos Fuentes)

1. INSIGHT

Environmental and resource problems can ultimately be traced back to consumption and lifestyles; consumption and production patterns in developing countries have been following the same patterns that were and are typical of most of their industrialized counterparts[1]—the difference is one of magnitude, but is likewise unsustainable (UNEP 1999a). The seventh goal of the Millennium Development Goals (MDG)[2] from the United Nations (UN) includes as Target 9: "Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources" (UN 2003). Principle 8 of the 1992 Rio Declaration on Environment and Development states that "to achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies"[3] (UN 1992). Thus, for developing countries (like Mexico) one of the

[1] For example, 88% of all trips in the United States are by car; unsurprisingly, transport accounts for more than 30% of US carbon dioxide emissions (Walsh 2007).

[2] It was in the city of Monterrey, Mexico where the eighth MDG was reaffirmed. This meeting elaborated how the seven goals can become a real fact: "Develop a global partnership for development". At the same time, each goal calls for particular attention to seven different but related areas: poverty, lack of education, gender inequality, child and maternal mortality, mortal diseases and environmental degradation. This research finds its broad justification within this last goal.

[3] In the same text, Principle 11 complements and states: "States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and development context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries." It fits then the question concerning the conditions that we have to take into account to get into this sustainable path (policies,

greatest challenges (besides demographic control) is to know how to move from consumption patterns based on quantitative values to enlightened consumption based on qualitative values. Primarily, as Piorkowsky (1998) states, *sustainable consumption* refers to the steady reduction of wasteful consumption levels of energy and other natural resources, i.e., improvements in efficiency and changes in lifestyle.

At the same time, urban areas are expanding rapidly and increasing stress on the natural environment[4]. In 2000 nearly half (48%) of the world's population lived in such areas, and this proportion is expected to grow by 2% per year; the urban population in developing regions will double from 2 billion (in 2003) to 3.9 billion in the year 2030 (UN 2004). However, urban centres are not only concentrations of people with harmful consequences at urban, regional, continental and global scales, but also centres of economic growth, education, technological advancements and culture. Cities present a special opportunity to manage a growing population in a sustainable way (Molina and Molina 2004)[5].

Of the many and various problems associated with urban areas, air pollution is one of the most important[6]. Chronic and infectious respiratory diseases are highly associated with air pollution; also, dispersion of locally generated pollutants has been well established in the case of acid deposition, climate change and stratospheric ozone depletion (Krupnick 2004). During the past century, air pollution of human origin has become a major and persistent problem in many urban areas around the world. Growing population and changing lifestyles continue concentrating air pollution in cities today. In 1992 the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) evaluated air quality in 20

measures and results) in a scenario like the Mexican one. So far the objectives and instruments, in cities like Mexico City for example, have not reflected the environmental and development context to which they apply.

[4] More than 60 million people are added to cities each year. Most of this expansion occurs in urban areas of developing countries, aggravating already backlogs in housing and infrastructure development (UN 2004). Also, by 2015, 23 of the 27 cities expected to reach 10 million will be in developing countries.

[5] On the other hand, one can find other statements such as "urbanization blinds the modern eye to ecological reality by separating people both spatially and psychologically from the ecosystems that support them" (Rees in Shumacher 1999). All in all, cities require resources—including energy—to sustain the increasingly consumer lifestyles of their inhabitants, and the task is to find the best possible way to do it.

[6] Definitions of air pollution and other related technical terms are provided in the Appendix B: Glossary; also, the List of Abbreviations and Acronyms includes some technical terms.

megacities[7] and found that air pollution was widespread; each had at least one major pollutant in excess of WHO health guidelines; 15 had at least two, and seven had three or more (UNEP/WHO 1992). These seven cities were Mexico City[8] (Mexico), Beijing (China), Cairo (Egypt), Jakarta (Indonesia), Los Angeles (USA), Sao Paolo (Brazil) and Moscow (Russia). Society has only recently become sufficiently aware and informed to take actions against this problem: In the case of Mexico City, which in 2000 had 18 million inhabitants and a density of 12,200 people/km^2, major air pollution control efforts started only a decade ago. On the one hand scientists have developed, for example, an understanding of smog formation and how to reduce smog levels, but on the other hand significant social and political barriers still must be overcome in order to implement solutions.

Transportation plays an integral role in cities: it provides benefits but also costs that can act to inhibit further benefits. The challenge at hand is to find the way to reap these benefits without incurring negative impacts. In terms of Ayres (1994), transportation gives a peculiar industrial metabolism to cities: it is not only a way to consume our transportation facilities and to produce displacements and movement of goods and services, but also a production of externalities and consumption of time. The above mentioned UNEP/WHO report called for the urgent need (mainly for the particular set of reviewed megacities) of more effective planning of energy requirements and transport in order to reduce human exposure to pollutants and to decrease risks to health and environment. Also, it revealed that motor vehicle traffic is a major source of air pollution in all these megacities and actually the most important source in half of them. In Mexico City, the transportation sector accounts for nearly all of the CO, 80% of the NO_x, 40% of the VOC, 20% of the SO_2 and 35% of the PM_{10} (CAM 2002). Given then that transportation is the greatest source of pollution, intervention is needed to reduce the sector's adverse impacts.

[7] Megacity is defined as an urban agglomeration with population of 10 million or more (UNEP/WHO 1992). The definition is arbitrary, as major urban centres often include people who are not located within a city's political boundaries (e.g., Mexico City).

[8] Mexico's megacity, referred to as Mexico City or the Mexico City Metropolitan Area (MCMA), includes 16 districts (*delegaciones*) within the Distrito Federal (DF), which is actually the capital city known internationally as Mexico City, and clusters of municipalities (*municipios*), including 37 in the State of Mexico (*Estado de México* or EM) and one in the State of Hidalgo. This definition is explained in detail in section 4.1 of Chapter Two.

Returning to consumption and lifestyles, one of the starkest differences in consumption patterns between developed and developing countries concerns motor vehicle ownership and, more importantly, the use of automobiles and their related gas emissions[9]. Technological and institutional advances have led to a reduction in vehicle emissions, but the number of vehicles in circulation and total vehicle kilometres travelled (VKT) has increased. To put it differently, the problem of air quality has not been solved by better motor vehicles[10]. As some studies have demonstrated (see the study of "The Automotive Industry" in UNEP 1999b), better fuel and motor technology may lower emissions per litre of fuel but may also increase VKT due to the reduced cost of travel, in turn increasing total emissions and cancelling the positive effect. Overall, motor vehicle emissions depend not only on technical issues (e.g., fuel and motor quality) but also on behavioural factors (e.g., better usage and buying conditions facilitate a more intensive use of automobiles). There are significant constraints on what fuel and technology improvements can deliver; in many cities reductions in per-vehicle emission levels have been offset by increases in the number and use of vehicles (Molina and Molina *op. cit.*).

Finally, from a modal share perspective and drawing upon the case of this empirical research, the most worrying trend in cities in developing countries is the massive shift toward lower capacity modes of transportation (i.e., private cars, taxis and minibuses) at the expense of collective modes of transportation such as subway and bus[11]. In Mexico City the number of private cars has in recent years accelerated at a rate of six percent annually; the existing transportation system has not adequately adapted to the changing socio-economic and increasingly urban distribution of the population with its resulting new displacement

[9] Air emissions from road transport not only reflect differences in the number of vehicles but also show a higher proportion of older, i.e., more polluting cars and trucks in developing countries. CO_2 emissions per capita might not be the best indicator to show the magnitude of the problem but rather emissions per kilometre travelled, e.g., for each million kilometres travelled, vehicles emitted 363 tonnes of $C0_2$ in the US, 450 tonnes in Spain, 802 tonnes in Turkey, 1159 tonnes in the Republic of Korea and 1752 tonnes in Mexico (UNEP 1999a).
[10] Piorkowsky (1998) highlights this issue through the classification of lifestyles, i.e., four lifestyle options for more sustainable household production and consumption. Regarding the "new technology style" (that focuses on avoiding reductions in the standard of living through technologies that are cleaner, more efficient and spare natural resources, e.g., by using low or zero-emission cars), there is little evidence to validate its assumption of a more far-reaching environmentally conscious consumer behaviour amongst adherents to this lifestyle option.
[11] For example, in 1986 electric transport was 22% of the transportation demand in Mexico City, as compared with less than 14% at the present. On the other hand, bus and taxi demand increased from 11% to 58% in the same period (CAM 2002).

patterns. The key question is how to balance the mobility needs of the population of cities like Mexico City with the environmental impacts of transportation activity. Ultimately, Mexico City expects continued economic growth that will drive transport demand still higher and require the integrated implementation of technological and social policy options. In this context, this research aims at understanding and modifying private automobile use as a contribution to better policies for reducing pollution caused by motorists in Mexico City, demonstrating with this unique case study, as every city is, a way to work toward a comprehensive understanding of the complex environmental problems found within every city.

2. OBJECTIVES AND RESEARCH QUESTIONS

In general, government interventions against the air pollution problem in cities began in the 1970s. In Mexico, significant efforts started in 1982 with the second Federal Environmental Legislation (i.e., LGEEPA), which established norms for industrial emissions. In Mexico City in 1989, the "No Driving Day" program (HNC) became mandatory[12]. Since then this program has been a permanent measure and a major component of air quality management programs. In 1990 the first integral programme against atmospheric pollution (i.e., PICCA) was implemented with a five-year time horizon. However, in recent years applied policies have not tackled fundamental issues like behaviour related to the consumption of transport at all. Among various and focused programs on transportation management (which include a workable vehicle verification program), as Connolly (1999) states, questions of, for example, gasoline prices, taxes, and subsidies are debated in purely economic terms, never as a potential tool for modifying transport behaviour and ultimately reducing pollution[13].

[12] It was in 1987 when an environmental group named *Mejora tu Ciudad* (Improve your city) persuaded the drivers in Mexico City to participate in a voluntary initiative to avoid use of cars once a week. The initial response was favourable, however, support declined rapidly due to lack of resources and promotion. The program was adopted again when local government deployed a short-term 'emergency program' during the winter months when the ozone concentrations were very high due to several thermal inversions.

[13] Efforts like the "Integrated Program on Urban, Regional and Global Air Pollution: Mexico City Case Study" initiated in 2000 at MIT by Nobel laureate Mario Molina are outstanding. The results of the first phase, summarized in Molina and Molina 2002, are a touchstone for this research.

To summarize, Mexico City, following the above mentioned unsustainable consumption patterns, has developed an "automobile dependence", which has not received adequate attention by either government or scientists. This dissertation builds on previous studies related to automobile dependence, urban sustainable development and the problem of air pollution and transportation in Mexico City by investigating the use of private automobiles and their impact on transport-related emissions.

Specifically, the objective of this study is to obtain an in-depth understanding of the preferences and constraints of private motorists in Mexico City, which includes the following:

(a) data on relevant factors and driving patterns;

(b) differences in the extent of pollution arising from environmentally friendlier driving;

(c) attitudes of motorists regarding the adoption of environmentally friendlier behaviour.

The basic research questions for each case are:

(a) What driving patterns are relevant for the current private motorists' situation in Mexico City[14], in particular for private automobiles in the Distrito Federal? What factors determine these patterns?

(b) What factors influence the driving decisions of the environmentally friendlier motorists? How is the motorist's behaviour regarding automobile use (i.e., to what extent does the motorist see and take into account the outputs of driving)?

[14] Distrito-Federal (DF) is the capital city of Mexico and the central part of the Mexico City Metropolitan Area (MCMA), and it is known internationally as Mexico City (See above footnote 7, and Section 4.1 of Chapter 2, for an extended explanation).

(c) How and under what conditions is a real switch to environmentally friendly alternatives related to automobile use possible (i.e., to what extent it is possible to modify the current motorists' behaviour)? How can the use of automobiles be optimized within the already existing transport management-programs? How different behaviour in motorists can be stimulated and what are the related implications?

Most economic studies about the problem of air pollution in Mexico City concentrate on the evaluation of the benefits and costs of improving air quality (e.g., Pedrero 1993; Cesar *et al.* 2002; Chapter 4 in Molina and Molina 2002). Other studies address the issues of traffic control and demand side management (e.g., Goddard 1997), but little attention has been paid to the behavioural aspects of transportation consumption as such. The studies have been silent on motorists' decisions about use of their automobiles. This study is an attempt to fill this knowledge gap. I expect that economic analysis will allow us to foresee to what extent policy instruments can promote or guide desirable behaviour patterns among private motorists.

3. THEORETICAL FRAMEWORK AND DATA FOR EMPIRICAL ANALYSIS

The analytical framework to be used takes into account that the essential nature of transportation is not only the distance travelled but also vehicle performance (and its environmental impacts). Motor vehicle use is reflected not only through pollutant emissions levels, but also through kilometres travelled; what matters is neither emissions nor kilometres alone but both. Particularly I expect that with the data collected every six months by the Vehicle Verification Program (VVP)[15] in the Distrito-Federal, it is possible to take pollutant emissions and kilometres travelled into account in the model. This will introduce a better tool to evaluate and control current automobile use and improve the already applied HNC program. In particular I follow the framework provided by Seel and Hufnagel (1994) where

[15] The mandatory emission inspection program in the MCMA, coupled to the HNC program.

activities and final outputs are more important and relevant than goods per se, mainly because of the activities' environmental impacts.

An important basis for this framework is Lancaster's model of consumer behaviour (1966), which offers the possibility of comparing goods with similar characteristics and different qualities, e.g., to compare two similar automobiles with different environmental impacts. We then move from the traditional approach, where commodities are the direct object of utility, to one where utility is derived from the properties or characteristics of commodities[16]. In general, the decision to use an automobile depends on the demand for the final outputs (i.e., kilometres travelled and, to some extent, associated and accepted pollutant emissions), the preference for driving a particular kind of motor vehicle, and the restrictions upon its operation.

The empirical analysis is based on two data sets. The first contains data collected in Distrito-Federal's *Verifi-Centros* (Centres for Verification) by the VVP, for respective periods of 2003 and 2004. The second is a survey about consumers' automobile preferences collected during first semester 2006 by the Mexican National Institute of Ecology (INE)-Environmental Economics Area. More details on the models and data are provided in the corresponding sections of the dissertation.

4. OVERVIEW

In order to answer the research questions, rather than a single (econometric) model, I use the Lancaster-Seel-Hufnagel theoretical model as a tool jointly with statistical data description and, importantly, a revision of previous studies related to the topic (going beyond a mere economic point of view). The aim is to adapt new elements to the already existing models, and in this way to attain a better framework for analysis that permits going beyond limited theoretical matters and to treat empirical evidence for the use of automobiles in Mexico.

[16] In other words, a car does not give utility per se but because its use, and that's why we need a different approach to analyse how people choose to use their cars, how they use different cars based (directly or indirectly and in some extent) on its performance.