Lund University International Master's Programme in Environmental Science

Personal Transportation in Athens.

Master's Thesis

By

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In memoriam of my grandfather,
Anastasios Vassiliadis

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Abstract

Due to the economic growth that Greece experienced the past decade, a significant increase of transport demand along with an enormous increase of the private vehicle fleet has been observed in Athens. Consequently, due to its small physical area, Athens has to deal with the problem of traffic congestion, which mainly occurs in the city centre and causes numerous environmental impacts, as well as disturbances to the economic and social life of the city. Thus, the foundation of a sustainable transport system is an absolute necessity for the city in order to fulfil the needs of Athenians in terms of a qualitative environment and a reliable and convenient transport system. This paper reviews the current passenger transport system in Athens, in order to analyse the problems that occur, with respect to the fundamental principles of sustainable transportation. Furthermore, with the support of relevant studies and past experience, an investigation of the most suitable solutions for Athens is attempted. Taking into consideration the particular characteristics of Athens, a potential solution through the implementation of a road-pricing scheme is principally suggested, along with additional measures to improve the city's transport system. The main findings are that road pricing would be able to reduce traffic congestion in Athens, if implemented on the boundaries of the inner city cordon. Moreover, it would facilitate a shift towards alternative modes of transport. However, in favour of the formation of a sustainable transport system, additional measures would be necessary, such as parking restrictions, car sharing and improvements of the public transport services. In addition, the revenue generated by a road pricing scheme would be capable of supporting the investments of the public transport system. The most important obstacles to the implementation of such a policy package seem to be low public and political acceptability, as well as the inadequate institutional framework of transport management in Athens. Economic costs are found to be less significant, mainly due to the potential redistribution of the revenues.

Key Words: traffic congestion, city cordon, external costs, atmospheric pollution, public transport, optimal modal shift, redistribution of revenues, public acceptability, jurisdiction

Table of Contents

List of Figures

List of Tables

List of Acronyms

Additional Registration Fee	ARF
Area License System	ALS
Athens Urban Transport Organisation	OASA
Causal Loop Diagram	CLD
Compressed Natural Gas	CNG
Carbon monoxide	CO
Carbon dioxide	CO_2
Electronic Road Pricing	ERP
European Currency Unit	ECU
European Environmental Agency	EEA
European Union	EU
Gross Domestic Product	GDP
Gross National Product	GNP
Global Positioning System	GPS
In vehicle Unit	IU
Mass Rapid Transport	MRT
Nitrogen oxides	NO_X
Nitrogen dioxide	NO_2
Norwegian krona	NOK
Organisation for Economic Co-operation and Development	OECD
Ozone	0_3
Polluter Pay Principle	PPP
Statistiska Centralbyrån	SCB
Swedish krona	SEK
Sulphur dioxide	SO_2
Stated Preference	SP
Volatile Organic Compound	VOC
Vehicle Quota System	VQS
World Bank Organisation	WBO
Willingness to Accept	WTA
Willingness to Pay	WTP

1.0 Introduction

Due to rapid economic growth, the transport sector has grown enormously during the last two decades in Greece and particularly in the capital city, Athens. The transport sector has contributed significantly to this economic growth but on the other hand it has simultaneously created problems in the Athens basin, such as traffic congestion. As a consequence, the quality if the environment and thus the living conditions for the inhabitants, has gradually deteriorated.

Suburban sprawl along with a large increase of car ownership, has led to an overload of the already inadequate road network. As a result, Athens cannot provide its residents either with a reasonable quality of environment, or an efficient passenger transport system. The deterioration of the environment is reflected in the considerable air and noise pollution, as well as on aesthetics deterioration in the city. At the same time, inefficiency of the transport system becomes evident because of a gradual decrease in the average traffic speed which often impedes car and bus riders, causing a waste of essential time for simple daily transportation.

The problems that arise from the increased demand for transportation, made transport a major issue in many European metropolitan cities and consequently for Athens too. The current passenger transport system in Athens lacks the prerequisites of sustainability. Thus, the need for a comprehensive transport policy, to promote sustainable transportation and sustainable mobility, is urgent. The way to achieve such an aim is to ensure the development of the transport systems which enhances the quality of living conditions and the urban environment.

1.1 Objectives

This study has four major objectives. The initial objective is to analyse personal transport in Athens, focusing on the problems that occur and the reasons for these problems in relation to the economic, societal and environmental realities of the city. As the following figure (figure 1.1) shows, transportation in this study will be considered as a part of a broader system, which involves economic, social, and environmental aspects.

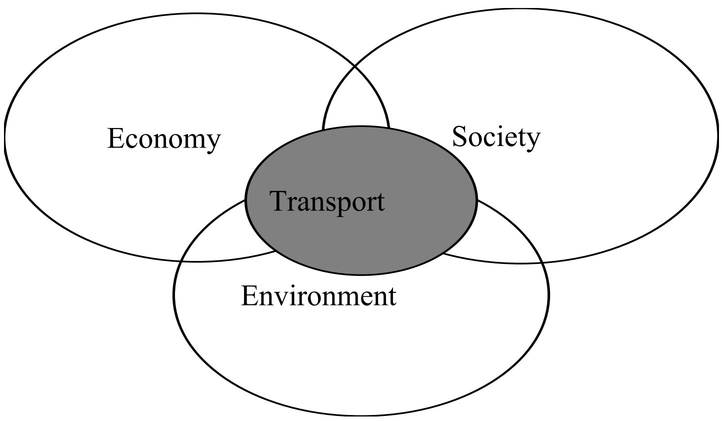


Figure 1.1: A simple but fundamental system

Secondly, an analysis of the problems that occur in Athens is attempted in comparison to the fundamental principles of sustainable transportation and in order to investigate whether or not the current transport system fulfils the prerequisites of sustainability. Thirdly, based on the experience of research projects (Transprice) and relevant cases (Singapore), the potential implementation of a road pricing scheme as a major policy instrument towards sustainability in Athens, is studied. In particular, the study attempts to analyse whether or not road pricing could be applicable in Athens as well as efficient enough to decrease car traffic to such an extend that fundamental principles of sustainable personal transportation could be fulfilled. On this point, additional policies to assist road pricing towards a formulation of a comprehensive policy package are presented, such as parking pricing, car-pooling and public transport improvements.

Finally, an estimate of the potential road pricing revenues is carried out, along with a discussion about its prospective use. An analysis of the possibility to subsidise the improvements of the public transport sector by an efficient redistribution of the revenues is also carried out.

1.2 Materials and methods

The method of this study is based on a combination of a comprehensive literature review with the implementation of basic systems analysis.

Literature review: An extensive literature review has been carried out, aiming to collect materials and gain knowledge about issues such as:

1. The definition of Sustainable transportation.
2. What road pricing is, how it can be implemented and what effects can be expected?
3. The particular characteristics of transportation in Athens with respect to the environmental, social and economic realities, such as: traffic trends, vehicle flows, land use, road network, transport demand, public transport, and environmental impacts.

A literature review has been completed in order to gain knowledge about the principles of sustainable transportation and the theoretical debate around the efficiency of road pricing. Moreover, an endeavour has been made in order to collect data about the traffic conditions in Athens, as well as about research projects related to the issue in a European level. Similar cases of metropolitan cities that introduced fiscal measurements have been studied. Official publications of authorities, public organizations and universities have been studied and compared, in order to support the validity of the data. Unfortunately, much of the technical data about traffic figures in Athens was available only in Greek language and therefore cannot be accessible for further investigation for any non-Greek reader.

Discussions with representatives of different authorities: Fruitful discussions with representatives of the authorities (Athens Urban Transport Organisation, Athens 2004, Ministry of Environment, Municipality of Athens, Aristotle University of Thessalonica, Trias SA) have been made in order to give more explanations on the data and the project that was studied in the literature review, and furthermore to share their experience and their personal -off the record- approach on the issues.

Systems analysis: Basic systems analysis has been used in order to demonstrate the connections and the interactions among the different factors in the system. Short causal loop diagrams and mental models have been used to that direction. Quantitative systems analysis though, has not been attempted mainly because of the size of the system.

Methodology of the Study

In the primary stage of this paper, the transport system in Athens will be examined along with an analysis of the problems that occur. This process will be carried out under the principles of sustainable transport as those are defined from the literature review. Furthermore, in support of the analysis for future possibilities, a survey of different studies will be carried out. The results of the studies will be combined with the theory about transport policies and particularly road pricing, in order to examine whether or not they can provide sustainable transportation in Athens. The analysis will attempt to compare the prerequisites of the most promising studies with the prerequisites of Athens, in order to analyse the possibilities of a future implementation of the most suitable policies in Athens with the aim of establishing a sustainable transport system. As figure 1.2 illustrates, sustainable transportation in Athens will be analysed using a combination of theory, past experience and relevant research on transport issues.

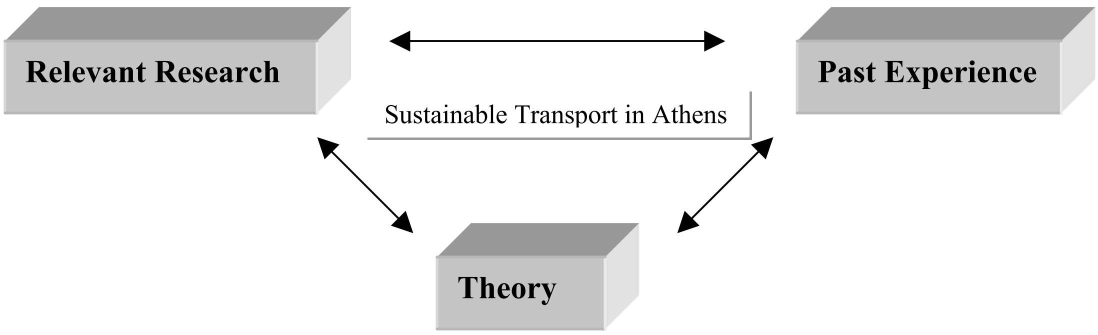


Figure 1.2: The methodological framework of the study

1.3 Scope and limitations

This study covers the issue of personal transportation in the city of Athens. Due to the size of the problem and the certain limitations of time and resources for a master thesis, the scope has to be limited to a qualitative analysis of the problems that occur from traffic congestion. Furthermore, regarding suggestions for potential improvements, a combination of demand and supply oriented policies will be examined. Issues of technological improvements (alternative fuels, new engines) for cars or more efficient driving patterns will not be considered as factors to change the system.

Although some of the tasks discussed in this paper are strictly economic, no intensive economic analysis have been attempted to explain technical issues such as optimal taxation, inflation, price elasticity and marginal utility.

Finally, the actual implementation of any policy that will be analysed in this paper is strongly related to external factors such as decision-making, political compliance and public acceptability, thus there is a considerable uncertainty regarding the feasibility of the schemes.

1.4 Thesis structure

The first chapter of this thesis is a general introduction to the topic along with the definition of the objectives, the scope and the limitations of this study. The methodology of the thesis is also described in that stage. Later on, in the second chapter, an extensive introduction to the case study in Athens is applied, with detailed information about facts and figures concerning transport in Athens. The analysis of the problem lies in the third chapter, where a simple causal loop diagram is also used to explain the interactions among the different factors. The fourth chapter is dedicated to the theoretical background of sustainable transportation, with particular reference to the origin of road pricing. In the fifth chapter, an analysis of the possibilities towards improvements in the system will be attempted, with respect to the theory that gained in the previous stage. A second causal loop diagram will be used to enhance understanding of the analysis. Finally, in the sixth and seventh chapters, a discussion about the potential applications and their results will be carried out, along with an analysis of the possible obstacles that might occur. Short conclusions are presented in the final chapter.

2.0 Introduction to the case study in Athens

In order to achieve a better understanding towards the analysis of the transport problems in Athens, a comprehensive presentation of the environmental, economic and social realities, is needed. Therefore, in the following chapter, a detailed background of the conditions in Athens will be situated.

2.1 Geography & population

The Athens basin is surrounded by seashore at the south, the mountains of Parnitha (1413m) and Penteli (1107m) on the north, and the mountains of Imitos (1026m) on the east and Egaleo (468m) on the west, forming a natural barrier for transport to and from the city basin (Athens Urban Transport Organization, 2000). Within the city, a variety of hills also create problems because of the frequent sloped streets of limited width that restrain the traffic. Other less important natural and artificial barriers for transport in Athens are the two terminals of the former Athens' airport, the numerous archaeological sites, the various gorges crossing the western suburbs and some few parks within the city centre.

Figure 2.1: Map of Athens
Source: Ministry of Environment, 2001

According to the latest survey from the Athens Urban Transport Organization (2000), the total land area of the basin is 1450km and the build up urban area is 544km^2 (35% of the total area). The city centre is located in the core of the basin and it spreads to an 11,76km^2 land area (figure 2.2). Within the city centre, the commercial centre or commercial triangle is located in a 3,86km^2 area. The urban sprawl of Athens continues to expand, mainly towards the north and the east, where areas with better environmental conditions still exist, and thus are more attractive to middle and higher income earners.

Regarding the population of the city, the latest census carried out from the National Statistical Service of Greece (2001) showed that almost 3.8 million people live in Athens and its suburbs. This population is comprised of 1.3 million households, with 66.8% of them owning at least one car. The dynamics of the population in Athens can be explained from previous censuses that show a population of 2.5 million people in 1971, 3 million in 1981 and 3.3 in 1991. The average increase of the population is for the moment 0,79% per year, with a rate of almost 10% for the northern-east suburbs (Athens Urban Transport Organisation, 2000. p.170). It is important though to mention that both the population and city expansion trends will soon reach the limits of Athens capacity, because of the mountains and the sea, which constitute an important natural barrier to growth. According to SAVE Action (1998d) the residential density is one of the largest in Europe (about 5,100 residents per km^2 of urban area).

2.2 The road network

The road infrastructure of the city is currently consists of an 8.600 km road network (Athens Urban Transport Organization, 2000, p.10). The major arterial network consists of 2000 km of roads, with the rest of the streets serving transport within the residential areas. According to the Athens Urban Transport Organization (2000, p.12), 76.5% of the streets have only one lane per direction, 17% have two lanes and 6.5% have three lanes per direction. The percentage of one-way streets reaches the significant amount of 30% of the total network. Regarding the width of the streets, evidence of the inadequacy of the network can be seen from the fact that 74% of the streets are less than 15 meters wide.

Parking restrictions in Athens are not extensive enough, given that parking is free along the 67% of the streets, partially free or with some limitations on 9% of the streets and totally banned on only 24% of the total network. Thus, most of the time, parked cars occupy vital transport space, which weakens the efficiency of the –already, insufficient- road network.

2.2.1 The inner circle or The “city cordon”

In the city centre, which covers a large part of the municipality of Athens, a system of traffic restraint (known as the city cordon) has been in operation since 1982 (SAVE Action, 1998a, p.15). The city cordon is identical to the city centre’s boundaries and therefore covers the same area of 11,76Km^2 (figure 2.2). The system allows access within a cordon covering the historical and commercial centre for private cars on alternate working days, corresponding to odd-even last digits on number plates. The initial expectations of the government, regarding the effectiveness of the scheme, have been principally fulfilled. The implementation of the city cordon has been satisfactory at the beginning. The traffic has been controlled much more efficiently than before and air pollution measurements showed significantly lower emissions. The efficiency of the new policy though, was soon to be undermined, because of drivers who tried to overcome the restraints by several methods. Significant increased double-car ownership, induced car use on allowed days, exemptions (special licences for journalists, state officials), some violations, and increased use of taxis (unofficially shared) and motorcycles are some well-established facts and developments of the past fifteen years, and are believed to amount to a severe reduction in the effectiveness of the inner circle.

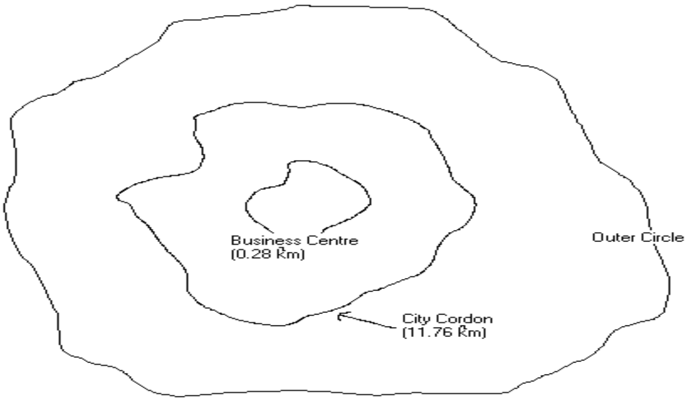


Figure2.2: Formulation of the City Cordons

2.2.2 The outer circle

An extension of the inner circle also exists, covering most of the city (figure 2.2). Vehicle use in the outer circle is only restricted in cases of higher levels of atmospheric pollution. However the outer circle was initially established during the 1980's when atmospheric pollution was much more severe than it is nowadays and is therefore practically out of use today. The outer circle though, could be useful in a future implementation of a road-pricing scheme, by setting the limits to the restricted area.

2.2.3 Infrastructure improvements

Due to the challenge of organising the Olympic Games of 2004 in Athens, Athens Road and Public Transport Organisation has undertaken a major investment for the improvement of road infrastructure. Hence, Athens is for the moment under an extensive transport infrastructure construction programme. Apart from the new airport and the recent opening of the subway (metro), the construction of 120 new km of road network and the upgrading of 90 km of the existing one are planned (Athens 2004, 2001). Furthermore, an additional 7.7 km of new network will be added to the metro system. According to the executive report of the Athens 2004 organisation committee (2001), the construction of two tramlines of 23.7 km length is under consideration, as well as the construction of a new light train (32km), which will connect the central railway station with the new airport.

2.3 Private car trends & car ownership

Greece's motorization trends faced a significant increase during the last ten years, mainly because of the economic growth of the country[1]. Due to better economic conditions and higher incomes, car ownership has become much more affordable than before. During the last decade in Athens, the number of private cars increased from 800,000 to 1,400,000 units. In addition to private cars, there are 200,000 mopeds being used in the Athens basin, and 16,000 taxis. After a short decrease in car sales between 1992-1994, caused by the abandonment of financial intensives from the government for the purchase of a catalyst car, distributors experienced a small but continuing increase in sales from 1995 and on (Figure 2.3)

[1] GDP growth was between 1.8% - 3.0% during the last ten years (OECD, 1999)

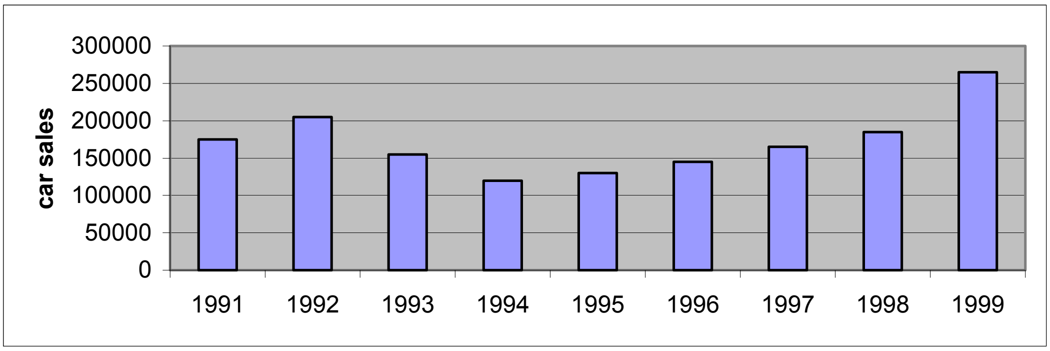


Figure 2.3: Car sales for Athens in period 1991-1999
Source: National Statistical Service of Greece, 2001

Hence, the annual increase of all private vehicles can be estimated at 40,000 units (Athens Urban Transport Organisation, 1998b). It becomes apparent that under the current car trends, car driving is the major contributor to traffic in Athens. Regarding the total vehicle kilometres driven in Athens, figure 2.4 clearly demonstrates the significant contribution of private cars (84.7%) to total traffic. Furthermore, figure 2.4 indicates the relatively high contribution of taxis (4.6%) to traffic, in comparison to public transport (1.8%).

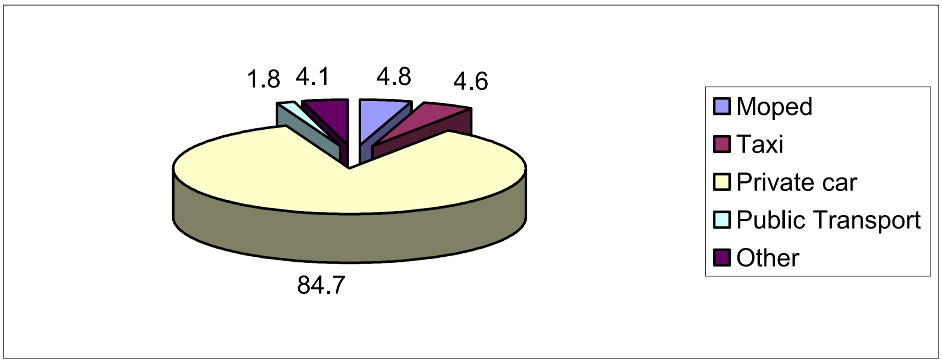


Figure 2.4: Division of vehicle kilometres on different transport modes in Athens
Source: Athens Urban Transport Organisation, 2000

Car Ownership

The available survey data on private car users from SAVE Action (1998D, p.10), give an average car ownership of 250 private passenger cars per 1000 inhabitants, or 0.8 cars per household. This number is lower than in other European cities and still below the level of the 400-cars/1000 inhabitants, which has been estimated as the upper limit of the network's capacity (Athens Urban Transport Organisation, 2000). Thus, it is believed that car ownership will keep rising in the next years. Car ownership is strongly related to the income and residential location of the households. According to Athens Urban Transport Organisation (2000, p.71) car ownership varies from 0.61 passenger cars per household in the central area, up to 1.16 cars/household in the northeastern suburbs. Furthermore, car ownership is found to be significantly higher in areas with higher incomes and social class groups (such as north-eastern suburbs). In conclusion, car ownership is significantly higher among wealthy people who live away from the centre.

2.4 Transport demand & Transport behaviour

It has been estimated that during a typical average working day the level of demand for transport in Athens is about 5.7 million trips[2] (in term of desires), which finally generate 6.3 million simple trips[3]. Most of the trips are made for work and educational purposes. Therefore, higher demand appears during the morning peak period (07:00-09:00) when most of the working and studying population travel towards their work places and schools, generating 1,1 million trips. As can be seen in figure 2.5, most of the daily transport occurs from people who travel to work. Social reasons and health services are also of major importance and thus their contribution to total demand is 21% of the daily trips. Shopping and education perform an equal share (11% and 12% respectively) and leisure is traditionally high to the level of 17%.

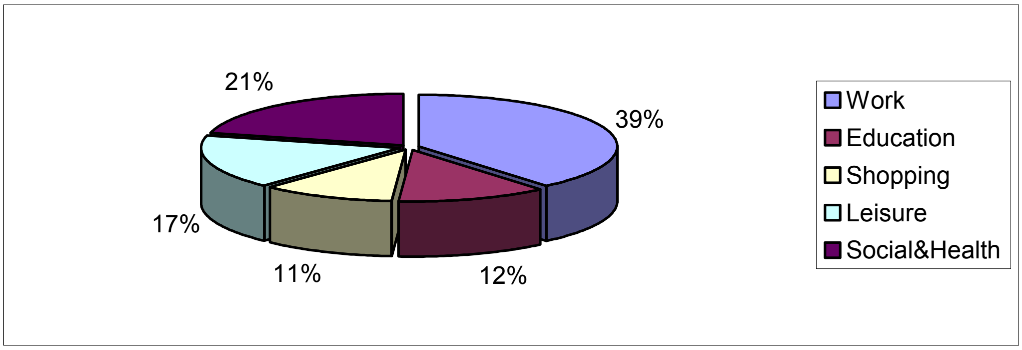


Figure 2.5: Division of transport, depending on the purpose of the trip in Athens (% of trips)
Source: Athens Urban Transport Organisation, 2000

During the last decade the number of trips made within the Athens basin has increased by 25%, due to the population increase and the increasing mobility. It has been estimated from Athens Urban Transport Organisation (2000) that the average trip generation rate, which indicates the mobility of the population, is 1.72 single mode trips per person per day, based on the total population. Taking into consideration that during a single day only 55% of the population carry out trips, the average trip generation rate for those who travel rises up to 3.5 trips per person. The trip generation rate is much higher for population groups with certain characteristics, such as employed, middle aged, car owners and males. Thus, it can be claimed that mobility varies according to income, age, car ownership (Figure 2.6a), gender and employment (Figure 2.6b). An important factor influencing the demand for transportation (likewise car ownership) in Athens is also the geographical residence of the citizens.

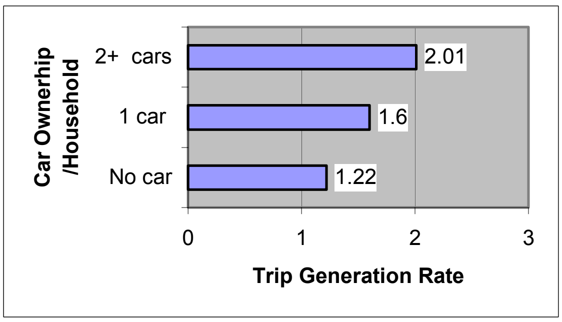


Figure 2.6a: Mobility index in relation to car ownership
Source: Athens Urban Transport Organisation, 2000

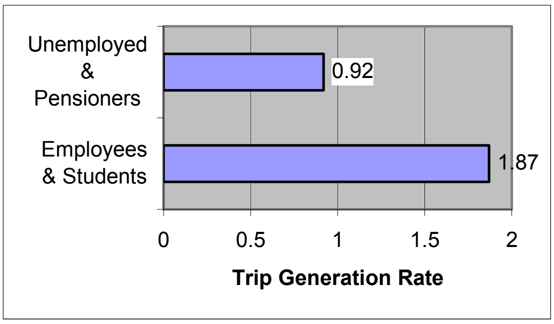


Figure 2.6b: Mobility index in relation to employment
Source: Athens Urban Transport Organisation, 2000

[2] Trip: a change of places caused by an activity (Athens Urban Transport Organisation, 2000)
[3] The final trip generation is higher than the demand for transport, due to transmodal trips

Moreover, it is important to mention that 30% of the total population consist of people with reduced mobility, such as old people, children or disabled persons.

More than half of the trips in Athens are made by motorised private modes. As figure 2.7 illustrates, almost 55% of transport is through private modes. During the last decade, the share of the public transport sector decreased by approximately 20%, due to the deterioration of the public services. Therefore the contribution of the public modes to total transportation fell from 40% to 32% (figure 2.7).

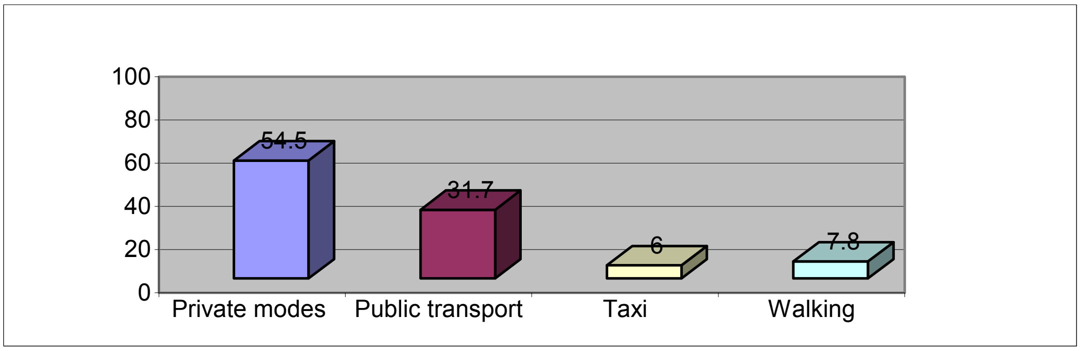


Figure 2.7: Distribution of trips according to transport modes (% of trips)
Source: Athens Urban Transport Organisation, 2000

When compared to other European cities, Athens has analogous modal shares for private car use and public transport use (SAVE Action, 1998d). Unlike other European cities, where biking has a modal share of 20%, the contribution of biking to transport is nearly zero in Athens, and walking is not considered as being efficient for long distances (SAVE Action, 1998d). On the other hand, Athens has by far the largest share of trips made by taxi among all the EU metropolitan cities (figure 2.7). It seems that walking is not popular among people in Athens. However it should be acknowledged that unlike in other European cities, Athens has a different definition for walk trips. This is due to the fact that only walk trips exceeding 15-minute duration are considered as part of the total travel demand. Nevertheless, it is certain that during the last two decades the percentage of trips made by walking has decreased in Athens.

As it can be seen in figure 2.8, the most common duration of daily trips lies between 10 to 60 minutes. Most of the trips seem to require 30-40 minutes.

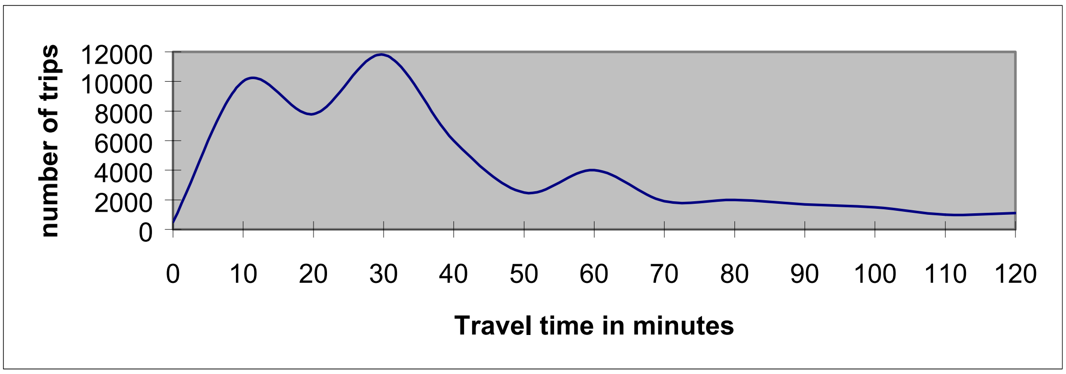


Figure 2.8: Trips volume according to travel time
Source: Athens Urban Transport Organisation, 2000

Trips from work back to home seem to require the most time among all types of trips[4]. As table 2.1 shows, public transport requires much more time than private modes to commit transportation.

Table 2.1: Average travel time according to transport modes and types of trips (Athens Urban Transport Organisation, 2000)

Transport Modes	Home - Work	Home - Other	Not Home-Based	Work - Home
Walking	20.9 min	23.6	27.4	23.7
Public Transport	44.4 min	42.1	35.9	45.3
Taxi	42.2 min	35.3	32.0	52.3
Private Car	29.7 min	29.7	29.4	31.4

Taking into consideration that average walking travel times refer to shorter distances, private modes seem to consume much less time per trip than any other modes. An indication of the deteriorated quality of the public transport services because of congestion can be observed in table 2.1, largely due to the fact that public services require much higher average travel times than private modes. An interesting point in the same table is that taxis do not justify their popularity among the travellers, since it seems that they are almost as slow as public transport. This can be explained mainly due to the fact that taxi drivers use to stop quite often during a ride, to pick up as many customers as it is possible for the same trip.

In conclusion, according to SAVE Action (1998d, p.8), the population of Athens is rather less mobile than in other large European cities. However, there still exist some uncertainty because trip definition and estimation differs from one city to another. Any significant variation between cities is due to social and economic factors, as well as its population and land use density, the spatial organisation of the society, the form of the transport networks and the overall city size.

2.5 Public Transport System

Public transportation in Athens is operated by the Athens Urban Transport Organization (OASA), which is a public organisation responsible for planning, co-ordinating and providing financing for all public transport networks within the greater Athens area. OASA uses a variety of different modes to provide transport services, such as thermal buses, electrical buses (trolleys) and metro.

Table 2.2: Public Transport Network (OASA, 1998b)

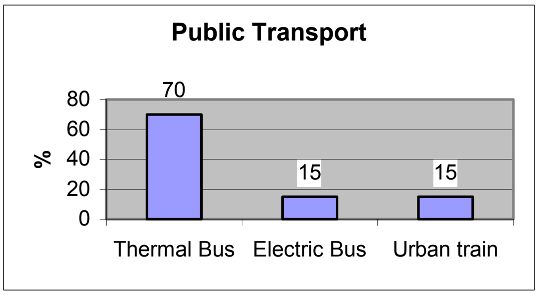
	Vehicles Available	Routes	Total Network Coverage	Passengers / Year
Bus	1600	280	5645 km	400 million
Trolley Bus	356	18	324 km	90 million
Metro	216	3	151 km	92 million [5]

The public transport network covers a total of 6.120km (both ways of line). As can be seen in table 2.2, the network operates through 1600 thermal buses that cover 280 different routes of 5645 km length, 356 trolley buses that cover 18 routes totalling 324 km length and 216 metro trains in 3 routes totalling 151 km (OASA, 1998b).

[4] The overall average length of all trips is estimated to a level of 6.7 km (Athens Urban Transport Organisation, 2000)

[5] Results are available for Line 1 only

As figure 2.9 illustrates, buses have the largest share among public transport modes, followed by equal shares of trolley (electric) buses and metro.



According to OASA (1998), there are 400 million passengers boarding on buses and 92 million passengers boarding on metro (1st line) on an annual base. Metro passengers are expected to increase in number due to the recent opening of two subway lines. However, no results are presently available from Attiko Metro S.A.

Figure 2.9: Passenger's preference among Public Transport modes
Source: Athens Urban Transport Organisation, 1998

The average length of a single bus line is 20 km (10km per direction), with an average of 23,4 bus stops per line (total bus stops are 7140). The metro system consists of 3 lines with a total length of 151Km (both ways) with 23 stations for the first line, 16 for the second and 18 for the third. The best average headway that can be performed is 4.5 minutes for the rush hours and 5.5 minutes for the rest of the day, resulting in an average of 197 trips per day and 45,000 vehicles Km per day for each of the lines.

The thermal buses commute almost 14000 trips per day, or an average of 53 trips per line. Taking into consideration that public transportation provides services for 18 hours per day, the average daily headway can be estimated to 20 minutes during a day or 15 minutes during the peak hours (Athens Urban Transport Organisation, 2000)

Regarding the legal operational framework of Public Transport, it is also worth noting that urban public transport is owned totally by the Greek state and therefore the principle of public benefit is more important than a profitable function of the transportation system.

Figure 2.10: Map of Athens Metro
Source: Attiko Metro S.A, 2001

As long as the state continues to subsidise the tickets by 52% of the total price (OASA, 1998), the ticket prices remain relatively low[6], especially in comparison to other European metropolitan cities. The number of the employees working to operate the entire system is approximately 15,000.

It is commonly acknowledged among authorities and people that the network-coverage of the public transport system is satisfactory in general and the majority of the population has a good access to at least one of the public transport modes. However, the citizens of Athens have a

[6] Bus ticket price: 0.35 Euro, Metro ticket price: 0.75 Euro, with 50% discount for all students and elderly people (OASA, 2001)

rather negative image of public transport (ICAP-DORNIER, 1993). This is for several reasons, such as the low service frequencies, the unreliability of bus schedules, the large delays, and the inefficient fare system[7].

2.6 Cyclists and pedestrians

Cycling in Athens was a very popular mode of transportation up to the early 1960's when private cars were extremely rare. The majority of blue-collar workers, likewise some of the white collars workers used to cycle every day from home to work and back. Nowadays, cycling is mostly considered as a sport among young people and not as a real transportation mode. Therefore, the contribution of cycling to the total amount of daily trips is practically zero.

According to Dr. Birbili (2001), a noteworthy lack of pedestrian streets is also apparent in Athens, where pedestrian streets are not only rare, but also limited in terms of size. Moreover, illegal parking often obstructs the existing walkways as well as the pedestrian crossings in many streets. However, in 1995 the municipality of Athens introduced an extended pedestrian network, covering the commercial triangle in the city centre where only few of the streets are open to traffic for particular periods of the day (commercial deliveries early the morning). Furthermore, due to an ambitious plan that is already under construction, the municipality is aiming to incorporate all of the archaeological sites in the centre of Athens into a partly pedestianised zone.

2.7 The effects of traffic congestion on the environment, society and economy

The significant increase in demand for transportation, because of the expansion of the city at the suburbs and the new modern life styles (which require increased mobility for leisure and socialise), have had a severe effect on the city 's traffic. As a result, the increased traffic, along with the inefficiency of the road network led to a high level of congestion within Athens, causing both direct and indirect problems for the economic and social life of the city, as well as for the environment.

2.7.1 Society

Firstly, the increased congestion poses a serious threat to social life. The social web is violently cracking, because of the enormous delays caused by traffic jams. Cars and passengers are often trapped in jam-packed streets, wasting much of their vital time. Moreover, traffic congestion poses a serious obstacle to socializing, because people unconsciously restrain themselves from going out or visiting friends, knowing that they might have to spend a lot of time commuting a single trip over a short distance.

Accidents

One of the major problems of transport in Greece and particularly in Athens is the high rate of traffic accidents. Traffic accidents in Athens consist an important social blow, due to the significantly high numbers of injuries and deaths among the population. In comparison to the population of the country and the number of cars in traffic, Greece is on the top of the list among all European Union's countries in terms of accidents and deaths from accidents (Frantzeskakis, Golias and Kanelaidis, 1999). Particularly in Athens, an average of 8,200

[7] All tickets (apart from monthly cards) are for one use only. Transrmodal trips cannot be supported from the current fare system

accidents occur every year[8], of which 300 are fatal (National Statistical Service of Greece, 2001). According to a recent survey, carried by Attiko Metro S.A (1998), private cars (taxis are included) are involved in more than half of the road accidents in Athens, followed by motorcycles. Figure 2.11a illustrates the distribution of road accidents on respect to the traffic modes involved:

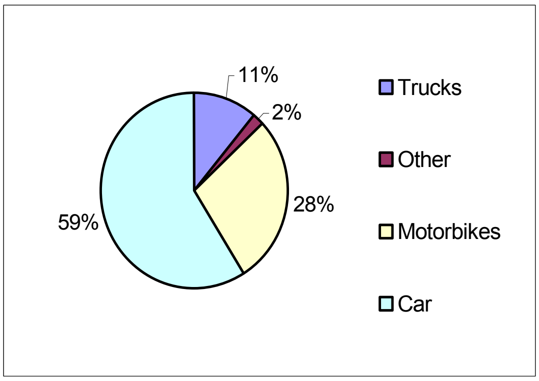


Figure 2.11a: Division of road accidents in terms of vehicle types involved
Source: Attiko Metro S.A, 1998

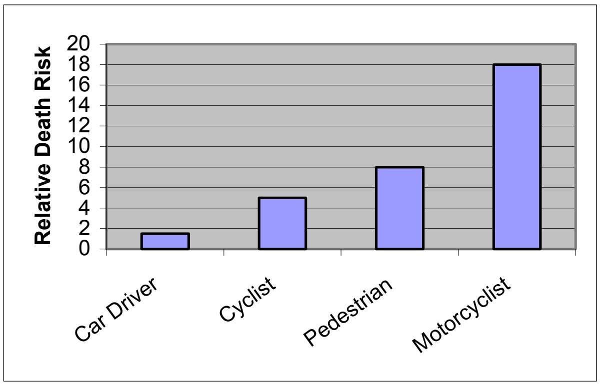


Figure 2.11b: Relative death risk per km travelled from different transport modes
Source: SCB, Police Report for Accidents, 1994

Furthermore, most of the accidents involve a crash between two vehicles and 25% of them take place when cars run over pedestrians indicating the major problem of safety for pedestrians among others. However, it should be mentioned that although deaths from car drivers are generally higher in absolute numbers, the relative risk for a fatal accident is much higher among motorcyclists and pedestrians (Holmberg and Hyden, 1996, p.236). As figure 2.11b shows, the relative death risk for a pedestrian is four times higher than for a car driver.

According to Eurostat (2001), the major reasons for the increased car accidents in Greece are: the inadequate infrastructure, high speeds, the large number of cars and the consumption of alcohol from drivers mainly during the weekend. It becomes apparent that the current transport system does not contribute satisfactory enough towards the safety of both drivers and pedestrians.

2.7.2 Economy

Environmental externalities:
Congestion causes both direct and indirect effects on the environment. The indirect effects can be briefly defined as the external costs of congestion (Peake, 1994). The phenomenon of external effects is one of the most common in the production of transport services. There are several methods for the calculation of external costs. Most commonly, estimations of external costs take under consideration factors such as human health, accidents, noise nuisance, loss of time, vegetation, loss of land, damages to materials and buildings and community severance. According to Maddison (1996, p.218), all the factors above have a monetary value which can be estimated using the economic principles of willingness to pay (WTP) and willingness to accept (WTA) (Freeman, 1993). The contribution of each factor to the total cost varies from one methodology to another or even from one country to another, and thus comparisons of any figures cannot be very accurate. The example of Rothengatter-Mauch study on transport external costs in the European Union (Rothengatter and Mauch, 1994) indicates that the

[8] This number includes only police reported accidents

major contributors towards external costs are: Accidents 54%, noise 14%, air pollution 16% and climate change 16%. Nevertheless, each methodology has its own validity, and there is no indication as to which one is the most efficient.

The effects of congestion on the environment and society can therefore be showed in economic figures. Taking into account factors such as human health, vegetation, degradation of infrastructure and damages to buildings, the external costs of congestion can be estimated to a level of 3.44 (0.1 SEK) drachmas per vehicle km. Considering that the operational cost[9] of a private car in Athens is 29.6 (0.85 SEK) drachmas per vehicle km (Attiko Metro, 1998, p.18), it seems that external costs from car driving are relatively low. Though, it has to be mentioned that the latter calculation of external cost does not include the factors of time consumption as well as traffic accidents, which apparently constitute one of the greatest costs to the economy. According to Eurostat (2001), the total economic cost of traffic accidents for the entire Greek state is approximately 1.2 trillion drachmas (34.3 billion SEK) per year. However, excluding accidents, external costs per vehicle km calculated to the total annual vehicle km in the Athens basin amount to 38.5 billion drachmas (1 billion SEK) per year.

As already mentioned, one of the major costs of congestion -apart from traffic accidents- is the cost of time wasted during travelling. Due to congestion, a significant number of employees, students, business executives, public officials and businesses waste additional time commuting. According to the same survey (Attiko Metro, 1998), more than half of the overall cost of congestion arises from time delays. Those delays have severe effects on the productivity of both people and businesses, resulting an indirect economic effect that can be estimated for the case of Athens at 500 billion drachmas (13 billion SEK) per year or 2% of the gross national product (GNP) of the country.

An effort to estimate the total external costs from congestion as well as to distinguish them with respect to the different traffic modes has been made by Maddison (1996). According to table 2.3, private cars (taxis are included) are the major contributors to the total external costs of road transport. In that case, the survey takes into consideration external costs of accidents, noise and air pollution and damage to buildings for the entire Greek state.

Table 2.3: Estimates of the total external costs of road transport in billions ECU (Maddison and Pearce, 1996)

Cars	Buses	M/cycles	Freight	Total	Total % of GDP
1.7	0.3	0.2	1.0	3.2	5.6

It can be concluded from the table, that the total external costs for the country constitute a considerable indirect expense to the economy. The total 5.6% of the GDP is the highest percentage among all European countries (apart from Portugal) and that difference arises mainly because of the high accident rate of the country (the highest in Europe).

A notably high economic cost -although a direct one- from congestion is the energy consumption. As it has been estimated from Attiko Metro (1998), fuel expenses constitute 70% of the total operational cost per vehicle km. Thus, the annual fuel consumption reaches a total of 1.1 billion litres (Athens Urban Transport Organisation, 2000, p.103), a figure that could be probably lower if traffic in the city was more efficient.

[9] Operation costs include: Fuel costs (70%), lubricant & tire costs (10%), service costs (20%)

2.7.3 Environment

Intensive car traffic has numerous consequences on the environment. Air pollution is the most important issue, mainly because of the various effects on human health, acidification and level of greenhouse gases. Noise pollution, vibrations, occupation of vital urban area and aesthetics are also important as indicators of a healthier environment and a good quality of life.

Air pollution

The problem of air pollution is a high priority in Athens. High concentrations of primary pollutants such as CO and photochemical pollutants such as NOx and O_3 are frequently observed. Atmospheric pollution becomes worse due to inadequate city planning and overpopulation in the area. Additional contributing factors towards the accumulation of pollution are the topography of the basin, which is surrounded by mountains, and the intense sunshine.

Atmospheric pollution in Athens was a major problem during the 1980's. However, due to a series of various anti-pollution measures that were taken by the authorities, there has been a general decrease trend towards the stabilization of pollutants in lower levels. In 1994, an action plan ("Attica SOS") against atmospheric pollution has been introduced from the Ministry of Environment (Department of Air Quality, 1998). The major objective of "Attica SOS" was to control the atmospheric pollution and stabilize the emissions to a reasonable level. Firstly, emission standards were introduced for each of the pollutants, along with alarm levels to activate immediate action in cases of high concentrations. According to the Joint Ministerial Decision that was announced in May 1993 (Ministry of Environment, 1998), the alert levels were set as in table 2.4:

Table 2.4: Alert levels for atmospheric pollution in Athens (Ministry of the Environment-Department of Air Quality, 1998)

Pollutant	Time Basis	Warning Level	Alert Level, 1^{st} Degree	Alert Level, 2^{nd} Degree
NO_2 ($\mu g/m^3$)	1 hour	400	500	700
CO (mg/m^3)	8 hours	20	25	35
O_3 ($\mu g/m^3$)	1 hour	180	360	500
SO_2 ($\mu g/m^3$)	24 hours	250	300	400
Smoke ($\mu g/m^3$)	24 hours	250	300	400

Furthermore, the country is already following the procedure to harmonise its legislation in line with EU directives regarding the air quality standards for smoke, nitrogen dioxide, sulphur dioxide, lead and ozone. In that point, it is useful to mention that the warning levels do not necessarily reflect any environmentally sustainable limits. The example of Swedish permissible limits for CO and NO_2 emissions, which are (on the same time basis) 6 mg/m^3 and 110 $\mu g/m^3$ respectively (Holmberg and Hyden, 1996, p.211), would suggest that the environmental "acceptable" emissions are much lower than those indicated in table 2.4.

Secondly, further action was decided as part of the "Attica SOS" strategic plan. Car emission certification was introduced, in order to oblige the drivers to check their cars for emissions every year and high penalties initiated for car owners who had no certification. Improvements in fuel quality have been also decided, upon a gradual reduction of sulphur content in gasoline. Following the technological innovation of catalyst cars, a gradual replacement of the vehicle fleet with new technology vehicles has also been achieved.

The appearance of catalytic cars and the gradual replacement of conventional ones (as a result of the incentive-policy introduced by the government at 1992) contributed to an average decrease of 25%-40% in air pollution from 1992 until the present. The operation of "Attica SOS" finally resulted in overall reduction of air pollution after 1992, which has been followed by a stabilisation trend during the last two years. As a consequence, the percentage of air pollution levels classified as high (warning level) – very high (alert level, 1st degree), dropped from 11.5% (1993) to 3% (1997), (Ministry of Environment, Department of Air quality, 1998).

However, the transport sector still contributes relatively more than any other activity to air pollution. As can be seen from figure 2.12, while industry is the main cause for sulphur dioxide and particular matter, transport modes consist the greater generator of nitrogen oxides, hydrocarbons and carbon monoxide. Private cars are responsible for more than half of the pollution caused by the transport modes. Nevertheless, the emission levels were much higher during 1980-1992, when most of the cars were non-catalytic.

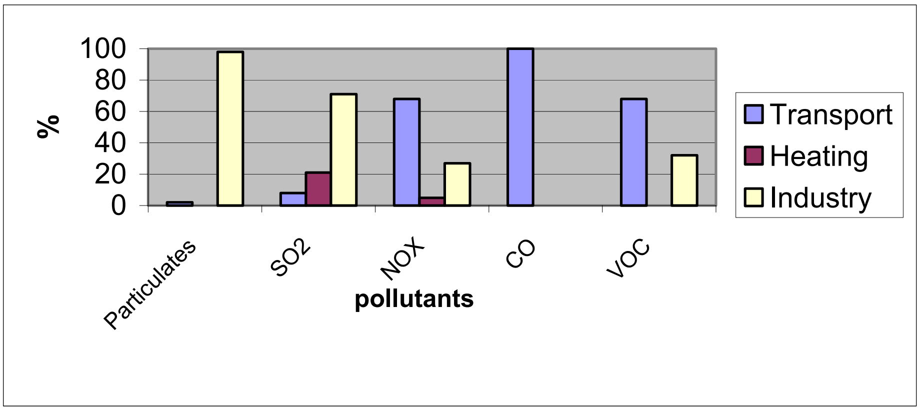


Figure 2.12: Pollutants per activity in Athens
Source: Ministry of Environment, 1998

The effects of air pollution on human health

The most important effects of air pollution in any metropolitan city are the human health hazards. There is various scientific literature identifying correlations between air pollutants and health impacts, which occur at levels of particle concentration commonly found in urban areas (Greenpeace Airlab, 1998, p.10). Health studies have established close associations between airborne particle concentrations and hospital admissions, respiratory symptoms and asthma symptoms. The elderly, young children and those with existing lung or heart disease, experience a greater response to a given particle exposure. Although there is so far no evidence that exposure to airborne particles alone can cause asthma, there is a connection, which links the exacerbation of asthmatic symptoms with exposure to particles. Other health studies have indicated a close association between daily airborne particle loading and cardio-pulmonary mortality. The main at risk group are those who already suffer a chronic respiratory illness. From a physiological perspective, it is well establish that "smaller" airborne particles, in the size range to 1 to 2.5 microns diameter, penetrate and deposit move deeply into the lungs (Möller, 2000).

However, there is no precise estimation of how many people die prematurely because of respiratory or cardiac problems that occur from air pollution. Such estimation would be difficult to be carried out, mainly due to the fact that most people are exposed to numerous different pollutants over their lifetimes.

The effects of air pollution on environment

Acidification is one of the major consequences of air pollution. Acidification can be defined as the process whereby air pollutants such as ammonia, sulphur dioxide and nitrogen oxides are converted into acid substances (European Environmental Agency, 2001). Acid substances can reach the earth surface either though acid rain or as gases and solid particles. The impacts of acidification can be mainly observed in forests and lakes where damages are severe, as well as in freshwater, and coastal ecosystems (Miller, 1999, p.478). Due to the recent stabilisation of sulphur dioxide and nitrogen oxide emissions, acidification is currently occurring at slower rates than before. However, the problem still exists and it can only be solved when emissions of acidifying pollutants fall below a level that nature can tolerate and neutralize.

The greenhouse effect is also an important consequence of air pollution. Greenhouse effect can be described as a natural procedure where atmospheric pollutants (greenhouse gases) and heat are trapped near earth's surface (Miller, 1999, p.472) causing a gradual increase in average temperatures at lower atmosphere levels. European Environmental Agency (2001) indicates, that due to enormous emissions of greenhouse gases and aerosols, a significant increase (+0.3^{o}C to +0.6^{o}C) of the annual mean temperatures has been detected during the past 100 years in Europe. Likewise acidification, greenhouse effect is a cross-border issue that exceeds the regional importance of environmental impacts and therefore requires coordinated initiatives across countries and sectors (Schipper, 2000 and Hughes, 1993).

Acidification and the greenhouse effect cause various impacts on the city environment. Although Athens -as a dense urban environment- is not considered as a place conducive to widespread vegetation, the impact of air pollution to the existing vegetation is relatively important. Air pollutants and especially ozone, can cause direct damages to the leaves of crop plants and trees when they enter the leaf pores (Miller, 1999, p.488). Major disturbances can also occur to the photosynthesis and plant growth procedure, with a consequent effect on the marasmus of the plant. In addition, aquatic life and coastal environments can also be considered under threat, mainly due to acidification. However, some of the effects are not always visible in the first place, but come to light after several years or decades.

The effects of air pollution on materials

Air pollution causes various damages to materials as well. The most important damage occurs on the building materials such as stone, concrete, metals, glass, and rubber. Air pollutants such as sulphur dioxide, sulphuric acid and particulate matter cause surface erosion, soiling and corrosion to the materials and thus they contribute to a gradual deterioration of the quality of the buildings (Miller, 1999, p.490). The significant contribution of air pollution to marble corrosion is the most important issue in Athens, because of the numerous marble statues and historical buildings that are exposed to air pollutants. A rough estimation from the Ministry of Environment (2001) indicated that the ruins on the famous Acropolis of Athens have deteriorated much more during the past 50 years than during the last 2000 years. Finally, an effect of minor importance is the deteriorating impact of air pollution to paints, paper, textiles and leather, which also causes plenty disturbances to the inhabitants.

Noise pollution

The gradual increase of traffic in Athens had considerable effects on the levels of noise pollution. According to surveys from the Greek Ministry of Environment (Department of Noise Abatement, 2000), more than 60% of the citizens of Athens suffer from high levels of noise emissions. Measurements on the most congested roads in Athens showed levels of 80-100dB during daytime and night hours as well. The contribution of motorcycles was at least of the same importance as the contribution of private cars in noise measurements. Due to the car traffic restrictions on the city inner-ring road, many Athenians have turned to motorcycles and mopeds as their transportation mode. Noise problems from motorcycles, especially due to tampering and lack of maintenance were enormous. The response from the ministry of environment to that particular problem was the implementation of an "on the spot" motorcycle noise measurement control in 1996, following the EU 78/1015/EEC directive on stationary motorcycle noise methods.

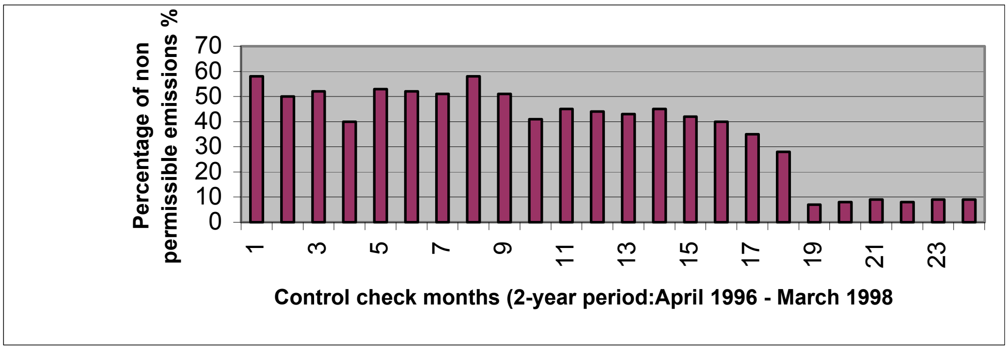


Figure 2.13: Temporal variation of the Athens noise control roadside check results
Source: Ministry of Environment, Division of Atmospheric pollution and noise control (2000)

The analysis of the results -as illustrated in figure 2.13- showed that whereas over 50% of the motorcycles checked before the measure found to exceed the permissible limits of noise emissions, only 10% of them found to exceed the limits after 18 months of the implementation of the check controls. No relative noise emission controls have ever been introduced for private cars and taxis on a regular basis. The present sample measurements in the main arterial roads in Athens, estimate that noise emissions from about 5% of cars and 25% of motorcycles are beyond the permissible limits.

The maximum permissible noise limits from permanent mechanical installations and all kinds of machinery, is defined in the Presidential Decree 1180 (Ministry of Environment, Department of Noise Abatement, 2000). This law applies for a 24 hours period and covers all urban areas as well. The maximum permissible noise emission is measured on the boarder-line between the source of noise and the potential receiver's property. According to the Greek legislation for urban noise emissions, the limits for noise pollution discriminate in respect to the different land-use type of areas as:

1. Legislated industrial areas: 70dB
2. Areas where industrial use dominates: 65dB
3. Areas where industrial uses co-exists with urban uses: 55dB
4. Urban areas: 50dB

However the legislation is in the process of been modified with the introduction of stricter noise limits.

3.0 The analysis of the problem

3.1 How does the problem generate? A systems analysis approach

The overall analysis of the passenger transportation in Athens can be demonstrated in the following causal loop diagram[10]:

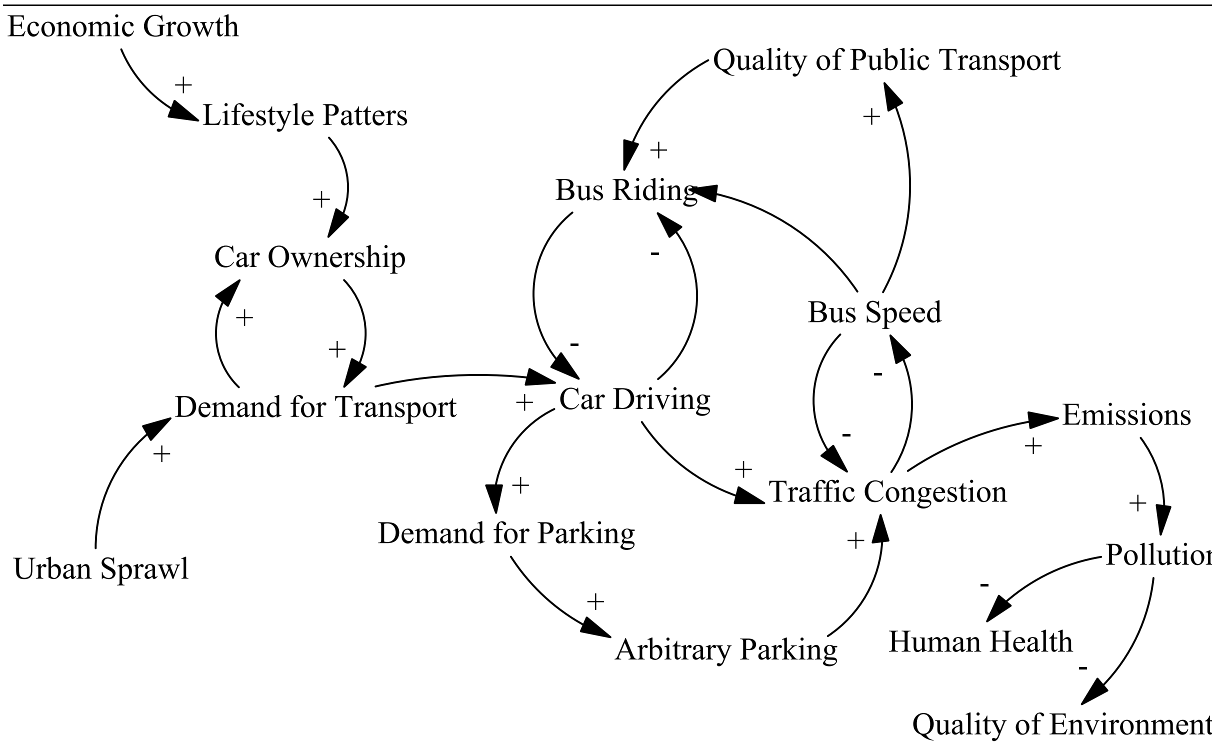


Figure 3.1: CLD of the passenger transport system in Athens

As mentioned before, the task of personal transportation in Athens is a complex system with lots of variables interacting with each other. The major problem appears with the decreased share of public transport modes and particularly of buses, in favour of private motorized modes, such as cars, in the total traffic volume. The increase of car driving causes an increase in emissions and thus a further deterioration of the environment. The following simple model (Figure 3.2) which arises from the causal loop diagram, demonstrates in particular the way, in which buses and cars interact to each other in the urban transport system:

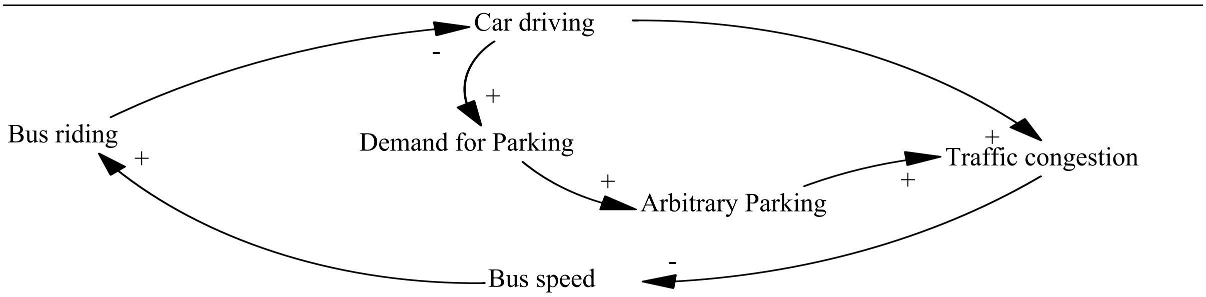


Figure 3.2: How bus riding decreases in favour of car use

[10] In favour of the better understanding of the model, it should be noted that the problem is stated in the centre of the diagram, whereas on the left the initial origin of the problem is illustrated. A simplified outcome of the problem is situated on the right part of the diagram.

The gradual increase in the number of private cars causes increased traffic congestion as well. An important contributing factor to traffic congestion in Athens is the absence of a well-organised parking system. According to a recent survey from Attiko Metro (1998) the daily demand for parking within the city centre, during the peak hours (10:00-13:00), is nearly 66,000 places, whereas the supply is only 58,000 parking places. Attiko Metro (1998) indicates that almost 80% of the parking takes place along the street side. Considering the fact that 45% of the total parking along the street side is illegal (Athens Urban Transport Organization, 2000, p.94) it becomes apparent that parked cars occupy vital space in the road network. A paradoxical phenomenon that appears from the latter survey is that whereas parking demand outstrips supply in terms of parking along the street side, there is a surplus of parking places in private lots[11]. In conclusion, it can be claimed that traffic congestion mainly occurs due to increased traffic and arbitrary parking.

As can be concluded from figure 3.1, the major consequence of congestion is a decrease in average speeds for both cars and public transport, but the effect is more severe for buses because of the major inefficiency that delays cause to the bus network. As a result of ongoing degradation of bus services, passengers finally shift to car driving. Regarding the latter claim, Athens Urban Transport Organisation (1998b) reports that approximately 9,000 bus users shift to private cars every year. It becomes obvious from the causal loop diagram that car driving undermines the competitiveness of the public transport. But what are the reasons for the increase in the number of private cars in the first place?

The major factor affecting car ownership is the economic growth (figure 3.1) of a country, and particularly the GNP per capita income. Once cars become more affordable, people do not hesitate to incur an additional cost in their budgets, in favour of more convenience, freedom, and independence in mobility (which are reflected in car driving). This choice is even more attractive, when the city authorities cannot provide an efficient and convenient public transport network. Moreover, due to economic growth, lifestyle patterns usually change and hence people have increased demand for mobility (SEBRU project, 1995).

An important factor affecting the level of transport demand is the expansion of the city. As mentioned in an earlier stage, Athens city is still spreading towards the east and northeast suburbs and therefore people have to commute longer distances in order to go reach the different parts of the city. It becomes apparent that due to the urban sprawl, demand for transportation is increasing and consequently car ownership is essential to provide transportation in a capable manner. Thus, as figure 3.1 indicates, city sprawl causes an increase in demand for transportation and consequently in car ownership as well[12]. It has also been found in the literature that car ownership itself might be able to increase demand for transportation. According to Athens Urban Transport Organisation (2000, p.72) people owning one car generate an average of 1.60 trips per day, whereas people without a car had an index of 1.22 trips on daily basis. Most importantly, people owning more than two cars were found to generate 2.01 trips per day.

Finally, the major problem that occurs from the increased car driving is traffic congestion. Traffic congestion has severe effects on the environment and it can be claimed that it

[11] Parking price at a private lot in Athens is approximately 3 Euros per hour

[12] As mentioned in Chapter 2, car ownership was approximately 1.16 cars/household in the north-eastern suburbs, whereas in the city centre was only 0.61 car/household

constitutes a major contribution to atmospheric pollution.[13] A strong correlation between traffic congestion and pollution is confirmed by the fact that emissions reach their higher levels during peak hours when congestion is high. As Greenpeace (1998,) indicates, SO_2 and CO emissions reach their maximum daily values during the morning (08:00-10:00) and evening (20:00-22:00) hours, whereas NO_2 peaks are measured during the morning (08:00-10:00) mainly hours. Furthermore, higher values of SO_2, NO_2, and CO have been measured in the city centre (Ministry of Environment-Department of Air Quality, 1998), indicating both that congestion occurs mainly within the centre and that emissions are higher in congested areas.

3.2 Why does Athens need immediate action?

Traffic congestion has been the major problem in Athens for the last two decades. The effects of traffic congestion on the quality of the environment have been severe for the citizens of Athens. The initiative of the Attica SOS programme had an initial success in controlling atmospheric pollution, and as already presented previously, most emissions have been reduced and later on stabilised during the past 7-8 years. However, the present reality in Athens is that traffic conditions continue to deteriorate and traffic congestion is a prevalent condition in the central area, spreading towards the suburbs as well. Furthermore, due to the gradual increase of the private car fleet (40,000 new cars every year) and the annual increase of traffic, which is 2.5% within the city centre and 3.5% on the suburbs (Athens Urban Transport Organisation, 2000, p.171), congestion is more likely to be exacerbated in the coming years, causing a consequent increase of atmospheric pollution. Thus, the accomplishments of the Attica SOS initiative are not enough to ensure the future preservation of air quality in Athens and a long term strategy for sustainable transportation is an absolute necessity in order to assure a better environment.

Furthermore, as Greenpeace states (Greenpeace Airlab, 1998), the application of "emission limits" as the indicator for sustainability is not adequate enough and therefore is not ethically acceptable. This is due to the fact that the limits themselves, do not only indicate the limits where further emissions are not permissible, but also justify and allow any emissions up to that level. In other words, "emission limits" point out that pollution is legitimate but only up to one level. Furthermore, the logic of average limits in respect to the average citizen or average health hazards does not respect the cases of more susceptible people such as elderly or young persons, and thus is not ethically acceptable. Nevertheless, the prospect of a sustainable urban environment goes far beyond the logic of pollution limits and requires a dynamic and continuous effort towards the limitation of atmospheric pollution.

In conclusion, a comprehensive policy strategy that aims to promote efficient and environmental friendly transportation is needed, in order to prevent the degradation of the environment and at the same time fulfil the needs of both citizens and businesses for qualitative transportation.

[13] Particularly in Athens, weather conditions and topography are also important factors to steer pollution to higher levels

4.0 Theoretical background

The major objective of this study is to analyse the problems that passenger transport causes in Athens and furthermore, to investigate policy measures towards a potential sustainable transportation system in the city. An important task to define in order to carry on with such an analysis is to clarify what sustainable urban transportation is and which are the mechanisms to make transport sustainable.

Firstly, it is necessary to underline that sustainable transportation is one of the tasks that arise from the concept of sustainable development. Sustainability is one of the most diversely applied issues among professionals and academics discussing development and the future. However, the most common definition of sustainability is the one that derives from the Brundtland Report (World commission on Environment and Development, 1989, p.43), which describes sustainability as the *"development that meets the needs of the present without compromising the ability if future generations to meet their own needs"*.

Since the first UN conference on the Human Environment in Stockholm (1972), sustainability has been mostly considered as a global issue, aiming to provide a better environment on a global scale. Thus, 113 nations committed to begin the process of undertaking environmental issues on a global scale. Nevertheless, sustainability has mostly been defined at the global and national level and only recently has begun to be applied to cities. Anders (1991,p.17), in a global review of the sustainable cities movement, pointed out that *"the sustainable cities movement seems united in its perception that the state of the environment demands action and that cities are an appropriate forum in which to act"*. Thereafter, an initial attempt to apply the principles of sustainability to cities has been made and suggestions for strategies to design and formulate sustainable cities have been introduced.

The overall goal of sustainability in a city has been described from Newman and Kenworthy (1999, p.7) as *"the reduction of the city 's use of natural resources and production of wastes, while simultaneously improving its liveability, so that it can fit within the capacities of local, regional and global ecosystems"*. The authors also underline the importance of developing appropriate indicators for sustainability in cities, claiming that by the year 2000, half of the world's population will be settle in dense urban areas. They finally indicate transportation as being an important factor to affect sustainability in a city and therefore they imply that sustainable transportation is an essential precondition towards urban sustainability.

4.1. What is Sustainable Transportation?

A definition of what is a sustainable transportation system is fundamental for a better understanding of the upcoming analysis. As claimed in the introduction, transportation is a complex task, which involves different dimensions and therefore it can only be examined in close relation to the broader environmental, social and economic realities. Thus, sustainable transportation is an issue that requires solutions not only in respect to environment, but to society and economy as well. A brief but accurate definition could be that a transportation system is considered as sustainable when it is environmentally friendly and at the same time efficient, economically viable, financially affordable and publicly acceptable (Polak and Heertje, 1993). How feasible is though to measure the above principles in a transport system?

The most appropriate way of doing this is to address a series of different objectives, constructing a basis where all instruments can be evaluated in terms of their contribution to sustainability. The Swedish Environmental Protection Agency (Skinner, 1999) distinguishes three different sets of objectives. Apart from the fundamental environmental objectives, a set of social and economic objectives is also considered as crucial to achieve sustainability in the transport sector. Table 4.1 illustrates the sustainability objectives for transport in accordance to the different perspectives:

Table 4.1: Sustainability objectives relating to Transport (Skinner, 1999)

Environmental Objectives	Social Objectives	Economic Objectives
Reduce toxic emissions and noise	Improve health and safety	Improve efficiency of transport system
Reduce greenhouse gas emissions	Improve aesthetic quality of built and rural environment	Improve transport-efficiency of economic activity
Reduce fossil fuel consumption	Improve accessibility	Improve efficiency of resource use
Reduce consumption of other non-renewable resources	Reduce (intra-generational) inequity	Support sustainable economic activity
Increase consumption of renewable resources	Reduce the impacts on future generations	
Minimise the impact of transport infrastructure for given travel demand		

Most of the environmental objectives aim to reduce pollution or resource uses, and are therefore uncontroversial. No extensive elaboration is needed for social objectives as well, which clearly focus on equity issues as well as on general improvements of quality of life. On the contrary, economic objectives are not as clear as the environmental and social objectives, mainly due to the fact that whatever is defined as economic sustainable does not necessarily provide economic growth and vice versa.

Skinner (1999) also claims that most of the objectives interact each other in a principally positive way. In other words, when transport policies aim to affect one of the sustainability objectives, it often influences some of the other objectives as well. A measure which aims to reduce fossil fuel consumption, for example, will probably affect positively other objectives, such as reducing toxic and greenhouse gas emissions or improving health and reducing the impacts on future generations. On the other hand, it might also happen in some rare cases, that a policy may increase sustainability in terms of one objective and cause negative side effects in others.

4.2 Transport policy strategies

The mass passenger transport situation of today puts forward the main question of how sustainable transportation can be achieved in practice. In order to advocate the principles of sustainable transportation and apply them in real cases, specific policy strategies have to be introduced. Furthermore, in order to implement the most suitable policies in each particular case, a detection of the most concrete policy goals to which instruments could be targeted is necessary (Route and Andersson, 1999).

Skinner (1999) suggests that a sharp definition of the initial policy goal might contribute to achieve a number of sustainability objectives and could prevent future controversial results. In other words, policy goals are those to provide the link between the sustainability objectives and the specific instruments.

Transport policy strategies can be classified according to their orientation. SAVE Action (1998a) summarises the transport policy strategies in four major categories:

1. Demand Oriented Policies:
    - Restricting traffic for private cars and Road pricing
    - Parking restrictions and Parking pricing
    - Speed limits
    - High occupancy lanes and Car sharing

2. Supply Oriented Policies
    - Improve public transport system in terms of quality, capacity, efficiency, comfort
    - Attractive fares
    - Dense bus stops
    - Bus & Ride facilities
    - Bus priority, bus lanes
    - New transport modes (metro, light trains)

3. Policies regarding Land Use and Urban Planning
    - Decentralisation policies
    - Controlling housing patterns
    - Improve network infrastructure

4. Policies regarding Energy efficiency & Innovative Technology
    - New engine & fuel technologies
    - Tax differentiation on fuels and vehicles
    - Promotion of non-polluting transport modes
    - Reduce need for travel through telecommunications and IT systems
    - Provide better public and private services (e-commerce)
    - Pre-trip information

A combination of demand oriented and supply oriented policies is the one of the major interest in this study and thus no further analysis on the rest of the policies will be attempted.
Regarding demand and supply oriented policies; several methods can be used for their implementation. Skinner (1998) and Hughes (1993) distinguish the instruments for sustainable transport into 1) Strategic instruments, 2) Fiscal instruments, and 3) Legislative and regulatory instruments. The measures to be examined in Athens arise from a combination of all the above instruments.

4.3 The theoretical debate around road pricing

Road pricing can be defined as the scheme where vehicle users are charged a direct fee for driving on a particular road or area. This charge can be achieved in many different ways. European Transport Pricing Initiative (2001) classifies the options of road pricing as: passes, tollbooths, electronic tolling, optical vehicle recognition and GPS-based pricing.

Road pricing has been an issue of major interest and discussion for economists for many years. The theoretical background of road pricing has been firstly investigated from Pigou and Knight, during the early 1920's (Morrison, 1986). Considering the fundamental distinction in transport analysis, between public and private goods and their use, Pigou developed the idea of optimal supply of public goods based on marginal utility theory and claimed that marginal benefit should equal marginal cost at the optimum level (Pigou, 1920). Later on, he introduced the concept of pollution taxes and suggested that "*polluters should face a tax based upon the estimated damage caused by their pollution emissions*" (Turner & Pearce, 1993, p.166). Following Pigou's analysis, Knight discussed the issue of property rights and claimed that it is the absence of exact property rights that causes the market failure in providing public goods when externalities appear (Knight, 1924). At that time, however, both Pigou and Knight could not perceive road pricing as a tool to solve congestion problems, but they provided the framework for the ongoing analysis on environmental externalities and the necessity of taxing the polluters for environmental damages. Thus, over the years, with congestion problems becoming more widespread, road pricing has come up as one of the key instruments to internalise environmental externalities from transport.

In short, even though an extensive economic analysis for road pricing is not the purpose of this paper, it can be briefly claimed that road pricing is one of the instruments that can be used to apply taxation theory for public goods (such as road networks) in practice, indicating how internalisation of environmental externalities can be partially achieved.

The major argument among the academics and professionals is whether or not road pricing can be used as an efficient method for controlling traffic congestion. According to Morrison (1986), road pricing has the potential to be an effective instrument towards restraining traffic in cities. In his survey, Morrison comes to the conclusion that road pricing could result in substantial net benefits when applied to congested cities. Moreover, he makes a reference to the Singapore experience (Willoughby,2000), where road pricing has been successfully implemented, in order to strengthen his claim that under the right institutional setting, such schemes can be applicable in practice. On the other hand, he doubts the political and public acceptability of road pricing in the prosperous western societies, arguing that the public and politicians are not particularly keen on accepting policies that introduce restrains and additional charges.

On the contrary, Mogridge (1986, p.165) argues that road pricing is not the proper solution to the problem of congestion in city centres. Although he acknowledges the contribution of road pricing towards the indication of the true level of demand for road space with a price which reflects the true costs, he strongly believes that road pricing cannot achieve any substantial reductions in traffic congestion. Mogridge claims that higher charges for car driving will only mean that the average car user will value his time and his convenience at a higher level and thus car users would probably be of higher income groups after road pricing. Mogridge 's analysis brings to the light one of the most essential issues of road pricing, which is equity. Similarly to any other tax instrument, road pricing has to deal with the major issue of who is actually paying the charge and who is gaining the benefits. However, someone could argue that this is not a particular problem of road pricing, since any taxation scheme has to cope with equity. Nevertheless, efficient design of an optimal pricing policy is required in any case of road pricing implementation in order to ensure that no equity problems will arise. Husock (1999), among others suggests that an efficient redistribution of the total revenues, either though investments to improve the road network and transportation system or by cross-subsidising alternative traffic modes, could be the finest technique to minimize any discriminations. Furthermore, he states that the actual success of road pricing, depends to a large extend on the authority that receives the revenues and the way of using them.

In conclusion, road pricing can be described as the most effective instrument for internalising the costs of congestion. This is because it incorporates external costs of transport into market prices. Although the initial cost of installing such a system is rather high, it would be probably exceeded quickly, due to the efficiency gains of corrected prices. Yet, road pricing cannot perfectly internalise external environmental costs, and as Button (1986) claimed it cannot be perceived as a panacea which would resolve all the city's transport difficulties. More pragmatically, road pricing can be definitely efficient when combined with other transport policy measures in order to produce a comprehensive traffic management package.

5.0 The analysis of the possibilities

5.1 How does Athens meet the need for a sustainable transport system?

Athens' society is facing the problems of traffic congestion, air pollution, and limited accessibility, as well as an overall deterioration of the quality of life. Hence, the overall conclusion after the examination of the environmental, economic and social conditions in Athens (and with respect to theory of sustainable transportation) is that the current personal transport system does not meet the prerequisites of sustainability. The strong need to improve passenger transportation in Athens, can most notably been demonstrated in efforts to change the modal shares of transport from private to public means. Thus, the development of a sustainable passenger transport system in Athens would require:

1. A significant decrease of car driving in favour of other modes, especially within the city centre where congestion and pollution is heavier,
2. The development of a high competitive Public Transport System which will be able to meet the needs of Athenians for qualitative, convenient and efficient urban transport,
3. An increase in car occupancy in order to attain a more efficient transportation through private cars

In order to fulfil the above requirements for a sustainable transport system in Athens, a comprehensive package of policy measures is needed. Among the different instruments that are studied in the literature, combinations of demand oriented and supply oriented policies are the most favourable for further examination. The relative studies and research projects indicated that the following measures as the most appropriate ones to accomplish the policy goals that described before:

1. Implementation of Road Pricing and parking restrictions,
2. Implementation of Bus Priority, Park and Ride facilities and improvements in the Bus Services,
3. Development of Car Sharing schemes, and car occupancy priority.

The evaluation of the current passenger transport situation in Athens puts forward the main question of how, with limited financial resources, a sophisticated system for public transport could be developed in order to provide sufficient transport services to the citizens of Athens. A comprehensive implementation of a road-pricing scheme could provide the funds to support innovations in the public transport sector, towards an optimal modal shift from car driving to public transport. Thus, the effective redistribution of road pricing revenues is also an issue of a major importance for the analysis of the possibilities.

5.2 Relevant research projects and case studies

Among a great variety of interesting projects and cases that studied in the literature review, two studies found to be the most promising for Athens. Regarding the theoretical field; out of the several research projects that have been examined, the most essential one was the Transprice project (Eurotrans Consulting Ltd, 1999), which investigated whether or not different pricing measures would be able to reduce car driving in favour of other transport modes. The importance of the project derives from the fact that it has been tested in Athens, both with systems modelling and demonstrating method.

The contribution of research, such as Transprice project, can provide useful information for the analysis that will be carried out later on. In favour of the validity of the analysis though, a relative case of successful implementation of fiscal policies has been found, in the study case of Singapore city (Willoughby, 2000), which was the first city to introduce severe fiscal measures towards a sustainable transport urban system. Relevant experiences of road pricing schemes have also been found in the cities of Bergen, Oslo, Trondheim (Norway)[14], and Paris (Gomez Ibanez and Small, 1994 and Willoughby C., 2000). However, the past experience from the Singapore case becomes more important for the analysis because of the similarities between the two cities (Singapore, Athens) and the similar prerequisites of their transport systems. A relative study of road pricing in Hong Kong (Dawson and Catling, 1986), was found to be very interesting because of the extensive tests of pricing systems, but finally is not presented in this paper, mainly because the scheme has never been implemented.

5.2.1 Introduction to the TransPrice Project

Transprice is a research project, initiated and funded from the European commission (General Directorate for Transport), aiming to investigate the role of trans modal integrated pricing measures and payment systems towards optimum modal split in European cities. The fundamental principles of the programme are:

- Develop policy objectives for optimising the modal split, where optimum is defined as the modal split at which the total generalised costs of both public and private transport are minimized,
- Aiming to internalise the environmental and other costs of transport systems
- Allowing for revenue allocation from road use charges to finance investment in public transport, non-motorised modes, road safety and environmental improvements.

The project was tested in eight European cities; Athens (Greece), Como (Italy), Madrid (Spain), Leeds (UK), York (UK), Graz (Austria), Gothenburg (Sweden) and Helsinki (Finland). In each of the cities, consulting companies, local authorities and universities have been involved in designing, testing and evaluating the project. The particular objectives of the project were:

- To investigate technical and financial options for integrated urban pricing
- To examine pricing strategies, tariffs and generalised cost structures for different modes of transport

[14] Road pricing in Norway was mainly aimed at revenue collection to fund infrastructure improvements. The scheme has mostly been implemented in a -broader than the city cordon- area and it had no intension to decrease traffic congestion. Thus, it found to be less important for the analysis of Athens site.

- To access the behavioural, operational, socio-economic, financial, land-use, environmental and energy impacts of transmodal pricing measures, including road use pricing and integrated payment systems.
- To model and demonstrate pricing and integrated payment systems in selected European countries, and to evaluate them using a common and comprehensive framework
- To investigate ways of exploiting traffic data and to disseminate the overall project results

A variety of different measures have been analysed, regarding the particular characteristics of the economy, society, geography and environment of each city. The measures were demand oriented aiming to restrict traffic, such as:

- Road use charging (cordon pricing, area licensing, expressway tolls)
- Parking charging (on and off street)
- Vehicle charging (purchase and fuel taxes)

as well as supply oriented, such as:

- Smart card payment systems for public transports
- Public transport fare structure and integrated payment systems
- Intermodality and park & ride
- Pedestrianisation and cycling facilities

Additional measures to improve traffic conditions and the efficiency of public transport has been considered, including:

- High occupancy vehicle lanes
- Bus lanes, bus priority
- Urban traffic control

The evaluation of the project has been considered as a multi criteria assessment, including economic, financial, environmental, energy efficiency, public acceptability and social equity criteria.

Actions and analyses in Athens

Particularly in Athens, the primary measure demonstrated was cordon pricing, along with the supplementary measures of park & ride facilities and public transport integrated fares and financing. The major task was to investigate the travel behaviour (mode choices) and the public acceptability of the measures, as well as an environmental analysis. Furthermore, congestion costs, dissemination activities and decision-making processes were examined.

All potential changes in travel behaviour were at first measured by means of a Stated Preference Survey (Eurotrans Consulting Ltd, 1999) with a Common Experimental Design involving combinations of the following attributes and alternative volumes within each one of them:

- Mode choice: Car Vs Public Transport Vs Park & Ride
- Car costs: +50 to + 100% from present operating and parking costs

- Car and public transport times: -20% and +20% from present times
- Public transport costs: -20% and +20% from present costs

Modelling and demonstration results

In the case of Athens, both demonstration and modelling was carried out, and a fairly close result between the two methods was found. The experimental implementation of road pricing in Athens indicated that 5-6% of car users transferred to public transport. Furthermore, 25% of all car users transferred to park & ride for a road use charge level of 1.5-2.3 Euros. When road pricing was tested on limited sample of car users in Athens, the price elasticity estimated at –0.2, meaning that on a network wide basis, car users would be eager to quit car driving with a 5:1 regime in favour of park & ride.

Regarding cordon pricing, the study pointed out a reduction of 5-20% in total distances travelled by private cars, for charge levels of 1-3 Euros. In terms of private cars entering the inner city cordon, estimations indicated reductions of 40-50% in respect to the charge level (1-3 Euros). With the implementation of different measures, the model indicated a demand for monthly travel cards for all modes of public transport at a level of 10% of total ticket sales.

Public and political acceptability

As mentioned before, an initial aim of the study was to investigate whether or not the policy measures would be acceptable to both the public and politicians. Public acceptability research was based on attitudinal questions following the method of Stated Preference Survey in addition to a behavioural research in the demonstration site. The final results showed that:

1. Public awareness for traffic congestion and associated environmental problems is high
2. Public awareness of pricing measures is relatively low, when compared to other demand oriented measures
3. Public acceptability of isolated pricing measures is low
4. Public acceptability of pricing measures increases substantially when pricing is presented as a part of an comprehensive package of measures, including revenue allocation to public transport investments
5. Political acceptability is strongly related to the public acceptability of the measures
6. Hypothecation of road use pricing revenues is becoming more politically acceptable and would possibly lead to higher overall acceptability of pricing measures

Conclusions and recommendations

Road use pricing is an effective way of changing the modal split from private car to public transport and park & ride and significant revenues can result from such an implementation. The cordon pricing method of road pricing is the most effective when applied to congested central areas, especially on peak hours, and therefore it could produce considerable results in Athens. Any further extensions of the measure to broader areas would not provide satisfactory additional benefits.

In conclusion, an effective urban transport pricing strategy requires the formulation of a package of supplementary measures and policies that can support the initial one. Along with cordon pricing measures, implementation of intermodality improvements is necessary, as much as integrated ticketing and development of public transport services.

5.2.2 Introduction to the Singapore Case

Singapore is one of the metropolitan cities, which first attempted to implement road-pricing measures in order to control traffic flows. Singapore has experienced over the past forty years a sensational economic development paralleled in very few other parts of the world. Due to the rapid economic growth and the limited physical space of the city, Singapore has had to give special attention to control the process of motorization. The implementation of road pricing in Singapore had successful results and thus it can also be used as a paradigm for further implementation of fiscal instruments to control traffic demand in other cities.

Background

Singapore city has great similarities with Athens. The major one is that it has physical barriers to both city expansion and transportation. Singapore is an island of limited physical space, surrounded by sea, likewise Athens that is surrounded by mountains (and sea on the south). Furthermore, Singapore has a population of 3.9 million inhabitants, occupying a total area of 647Km^2. The built-up area is 322Km^2 (49.7% of the total) and the average trip generation rate is 1.8 per person on a daily basis (Willoughby, 2000). When compared to Athens (table 5.1) Singapore is found to have similar transport occurrence figures, mainly due to the equal populations and transportation demand.

Table 5.1: Similarities between Athens and Singapore today (OASA, 1998b and Willoughby, 2000)

	Total Land Area	Built-up Areas	Percentage to total area	Population	Transport Demand	Average Trip Rate
Athens	1450 Km^2	544 Km^2	35%	3.8 million	6.3 mil. Trips	1.72 per pers.
Singapore	647 Km^2	322 Km^2	49.7%	3.9 million	7 mil. Trips	1.8 per pers.

Similarly to Athens, the total motorised trips per day have been estimated at 7 million. Furthermore, table 5.2 illustrates how land use is distinguished in both Singapore and Athens under the following aspects:

Table 5.2: Land use in Singapore and Athens (Willoughby, 2000 and Athens Urban Transport Organization (OASA), 2000)

Land Use	*Singapore*	*Athens*
Residence	15%	37%
Industry	5.9%	4%
Commerce	2.3%	1%
Transportation (including streets)	15%	13%
Agriculture	14%	1.5%
Open Areas	13.4%	23%
Leisure-Sports and Local Services	18.1%	14.5%
Land under Clearance - Other use	16.3%	6%
Total	100%	100%

It should be noted that the comparison of the figures in table 5.2 cannot be precise, because of the different methods that the two cities use in order to classify land uses. Furthermore, it could be claimed that some of the uses, might include different particular services within the category. Taking as an example Local Services (table 5.2), the data from Singapore include education in that same category, whereas in Athens health services are under consideration instead. Nevertheless, table 5.2 can truthful illustrate both the similarities and the differences between land use in the two cities.

The Pricing Schemes

As mentioned before, the Singapore government led the way in traffic demand management by implementing a variety of policies not previously used elsewhere. The major instrument was the implementation of road pricing. The initial method was the Area Licence Scheme (Gomez-Ibanez, 1994, p.11). Later on, the Vehicle Quota System (Willoughby, 2000, p.14) was implemented. Finally, following many years of extensive preparation, Singapore introduced the Electronic Road Pricing scheme (Willoughby, 2000, p.16), a high technology method that gives absolutely reliable results with less complexity and inconvenience for the car users. Along with the road pricing schemes, the Singapore government introduced a series of different measures to accompany road pricing, such as parking pricing, registration and purchase taxes, as well as car import duties. At the same time, improvements to public transport were made as well as improvements to the road infrastructure. Table 5.3 presents under a historical review, the most important measures introduced towards private cars in Singapore.

Table 5.3: Singapore policies towards cars (Willoughby, 2000)

1968: Communications Ministry re-established, 30% Import Duty on cars
1970: Bus service reform begins.
1972: Import Duties and Additional Registration Fee (ARF) increased
1973: Unified Singapore Bus Services formed
1974: ARF raised to 55%. Road Investment begins steep climb
June 1975: Area License Scheme (ALS) begins
Dec.1975: ARF raised to 100% and Preferential ARF introduced
1976: 50% of Singapore residents accommodated in HDB flats
1978: ARF raised to 125%
1980: ARF raised to 150%
1981: Completion first two major expressways: Pan-Island & East Coast Parkway
May 1982: MRT finally decided
Nov.1987: MRT begins partial operation
1985-88: Further Expressway completions
June 1989:ALS extended to car pools, goods vehicles & evening peak
Jan.1990: Vehicle Quota System (VQS) decided
May 1990: VQS comes into operation
July 1990: MRT (42 stations) completed
Jan.1994: ALS extended to whole day 7:30-19:00
1995: Road Pricing System (RPS) on one expressway
1997: RPS extended to further expressways
April-Sept.1998: Electronic Pricing System begins
Sept.1999: ERP extended to 7 access/by pass highways

Area Licence System:

The first time that Singapore attempted to operate a road pricing system was back in 1975, with the implementation of the Area Licence System. According to this system, all motorists had to purchase and display a paper licence in order to enter the restricted central zone of the city. Licence papers with different shapes and colours were used for different vehicles and months, in order to make spotting a lot easier for the police. The restricted zone covered most of the central area to a 600 hectares extent and the price of the daily licence was S$3.00 per day (S$60 per month) for those who wanted to enter the zone during peak morning hours. Along with the licence scheme, parking charges were raised, and therefore the overall cost of driving a car has become almost double than before. The benefits of the new system emerged almost immediately, showing a decrease of 47% in traffic volume within the centre and an increase from 18 to 35Km/h of the average speed. As it can be seen in table 5.4, the daily traffic entering the restricted zone had mostly been reduced for taxis and private cars.

Table 5.4: Daily traffic entering Singapore's Restricted Zone (Gomez-Ibanez and Small, 1994)

During Restricted Hours (7:30-9:30)	Before ALS (March 1975)	After ALS (July 1975)	Difference
All vehicles	55.313	29.532	-47%
Cars	32.421	8.130	-75%
Taxis	7.397	1.248	-83%
Carpools	2.334	3.581	+53%
Trucks	1.572	3.557	+126%

On the other hand there has been a significant increase in traffic caused by carpools and trucks, mainly due to their exemption from the charges. According to an extensive evaluation by the World Bank (Gomez-Ibanez and Small, 1994), the reductions in cars and taxis were primarily due to travellers shifting to carpools and public transport, and secondly due to travellers changing their routes and hours of travel. As it was initially expected, the traffic entering the restricted zone before and right after the restricted hours increased 17% and 10% respectively for all vehicles. Furthermore, while average traffic speeds increased within the restricted zone, a significant decrease of 20% in average speeds has been observed on the ring road, where traffic increased because of the drivers who wanted to bypass the restricted zone. Finally, according to the World Bank evaluation, no severe effects have been detected for any business activity in the centre, mainly due to the fact that most of the stores used to open at 10:00.

The results of the Area Licence Scheme can also be seen in the long run, mainly through the modal shift that occurred after the implementation of the system. As can be seen from table 5.5, the share of the private car to total transportation gradually declined in favour of public transport modes, such as bus and urban rail.

Table 5.5: Mode used by commuters to Singapore Restricted Zone, 1975-1988 (% of trips) (Gomez-Ibanez and Small, 1994)

Mode	*Before ALS*	*1976*	*1983*	*1988*
Automobiles	56%	46%	23%	23%
Bus	33%	46%	69%	55%
Rail transit	-	-	-	11%
Motorcycle	7%	6%	6%	8%
Other	4%	2%	2%	3%

Implementation of Electronic Road Pricing scheme

In 1998, after the implementation of various fiscal measurements, Singapore was the first city to introduce Electronic Road Pricing (ERP), an advanced electronic system of road pricing. The new system replaced the manual one, and the first two gantries started operating along the East Coast Parkway (table 5.6). Later on, 41 additional ERP control points launched from the Land Transport Authority (LTA). Due to the high capacity of the system, which is designed to support up to 100 control points, the authorities consider extending the operation of the system to the Outer Ring Road.

Table 5.6: The operational schedule for ERP System (Husock, 1999)

ERP System	Expressways	Central Business District	Outer Ring Road
Gantries	10	28	3
Operational Hours	7:30 – 9:30	7:30 – 19:00	7:30 – 9:30

System infrastructure
The system consists of three major components: The in-vehicle unit (IU), the gantry and the central computer system, which supports the whole operation. Each time a vehicle passes through an ERP gantry, the in-vehicle device deducts the appropriate charges from a smart card. Smart cards are easy to refill, since their value can be topped up at automatic teller machines, available at most gas stations, post offices and banks. The most important advantage of the system is that the approaching vehicle doesn't have to stop before the gantry in order to be charged. The system is designed to detect the in-vehicle devices under all types of traffic conditions. ERP can perform with reasonable accuracy, under stop-go conditions, cutting across lanes driving, or even when vehicle speeds are up to 120Km/h.

Evaluation of the Singapore case

The introduction of ERP system in Singapore evaluated as highly efficient in controlling the traffic within the centre of the city. The initial expectations of the government with regards to controlling congestion and pollution in the central business district, has been largely fulfilled. ERP has resulted a significant decrease of 13% in the number of cars entering the business centre, from 270,000 down to 235,000 per day. Furthermore, the motorization restraints had no major negative side effects on the commercial operation of the central business centre, and no economic, financial or societal problems ever appeared as a consequence of the restraints. The major achievement of the new scheme has been the high level of public acceptability, mainly due to the reductions in registration fees that the government offered in order to minimize the total costs of car driving for the drivers and make clear to the public that ERP was not a "milk-cow" policy to generate revenues for the state.

Evaluation of ERP system

+	-
High reliability	High initial cost of implementation
Significant reduction in traffic congestion	Minor interference from trunk radio network
Significant increase in average traffic speed	
High public acceptability	
Low violations (less than 0.3%)	

5.3 Why Road Pricing in Athens?

Several different policies could be used in an attempt to achieve sustainability. A reasonable question could be, why road pricing should be considered as the major instrument to promote sustainability particularly in Athens. As mentioned previously, the operational cost of a private car –although higher in absolute price- is relatively low when compared to the external costs of congestion. Moreover, recent surveys (Attiko Metro, 1998) show that this cost is expected to become lower in the near future, mainly because of the technological innovation in engines, which will consume less fuel. It is widely accepted that car driving generates an additional cost to society, mainly due to traffic accidents, atmospheric & noise pollution, loss of time and land occupation. An estimation of the total public cost, which is not finally paid in any direct or indirect way by the car users, has been attempted in 1998 (Deloukas, 1998). According to the research, the total public costs were approximately 180 billion drachmas (5.2 billion SEK) per year. This amount can be considered as an invisible subsidisation of private cars. Furthermore, it constitutes a significant comparative advantage in favour of car driving, and it weakens the competitiveness of the public transport systems.

It can be concluded from the literature review, that road pricing is an effective instrument towards the internalisation of external costs of congestion, and a good indicator for the real value (or market price) of road usage. Furthermore, the main characteristic of road pricing schemes is the increase of the public transport modal share. Thus, it seems capable enough of meeting the major needs of the transport system in Athens.

An additional reason to support the implementation of road pricing in Athens can be seen in the particular characteristics of Athens transport network, which seem to facilitate the scheme. Likewise in Singapore, the overall geography and the layout of the main road network of Athens are rather favourable towards implementing road pricing as a traffic restriction measure. According to SAVE Action (1998b, p.23), arterial roads are limited in number and mostly radial to the city centre. Moreover, the numerous steep hills and the ring road which surround the city centre constitute a set of geographic barriers, leaving no serious practical problems to implement this scheme, especially when aimed at reducing traffic through the city centre.

5.4 The Causal Loop Diagram

Taking as reference the causal loop diagram of the problem analysis, and by adding into the diagram the suggested implications, a comprehensive diagram can be developed as follows:

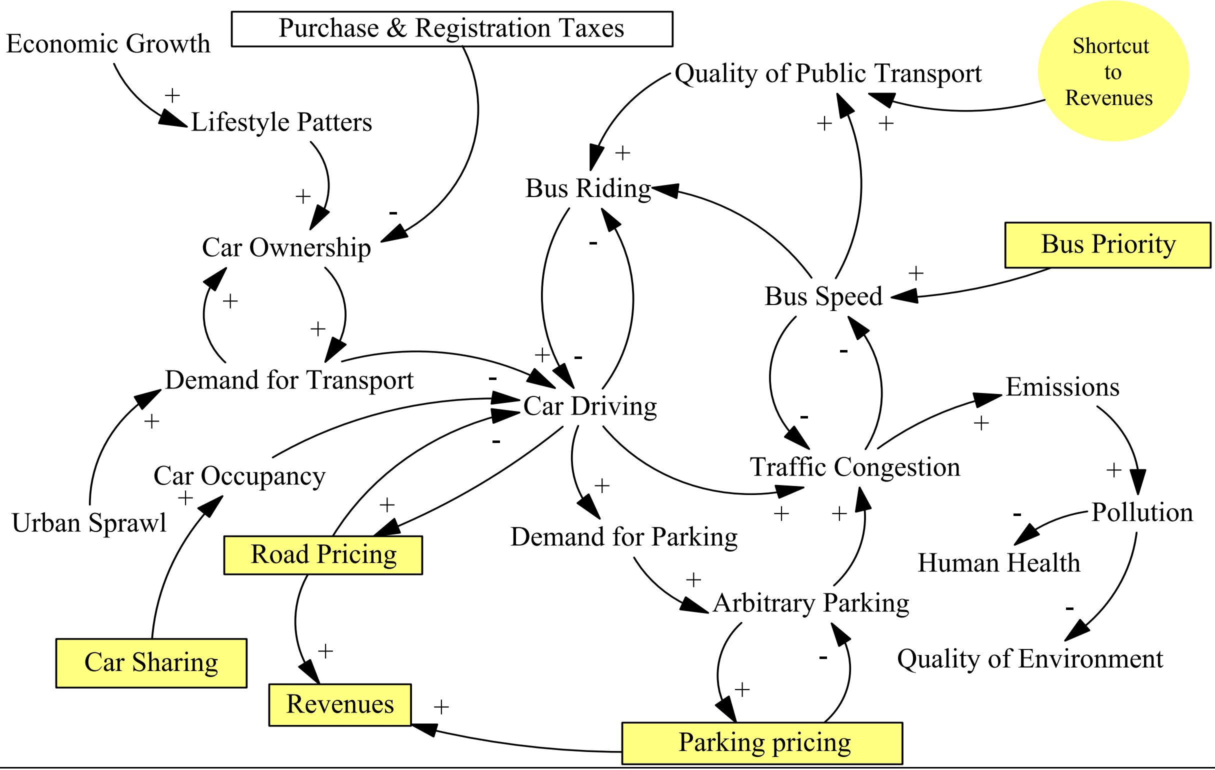


Figure 5.1: CLD of the possibilities

As can be seen from the model, the major characteristics of the system are the high volume of car driving and the arbitrary parking. The implementation of a road-pricing scheme could increase the cost of driving and therefore the level of driving itself. Furthermore, a parking pricing policy would restrict drivers from travelling towards the city centre. The successful experience of Singapore, where initial reduction of vehicle flow was approximately 47%, indicates the great potential of the scheme towards the restriction of car driving in the centre.

Both policies would result a reduction in traffic congestion and at the same time would raise revenues from those who prefer to use their car and who could afford the charges. The greater the number of the people would preferring to continue driving (and thus parking as well) the greater the revenue that would be collected. By using the revenues for the improvement of the public transport services, an alternative could be offered to those who wouldn't be able or keen to drive, through a more attractive public transport. Due to car restrictions, and with the implementation of bus priority, public transport could be faster as well, since the reduction in traffic congestion would cause an increase in the average speeds for buses.

Furthermore, knowing that the current car occupancy trend is only 1.3 persons/car, the development of car sharing facilities could assist to more efficient car transportation, through higher car occupancies. As the Berlin experience[15] indicated, car sharing can contribute positively in that direction.

The overall result would be a decrease of traffic congestion within the city centre and thus, and a direct decline in emissions and atmospheric pollution as well.

Alternatively, registration and purchase taxes could be implemented, in order to reduce car ownership. However, this should be considered in conjunction with the other fiscal measures (road pricing, parking pricing) in order to achieve the optimal total charges for car users. A rough estimation of charge levels would probably lead to severe side effects for the economy (European Commission, 1996). Thus, a comprehensive cost-benefit analysis is an absolute requirement, in order to achieve the optimum results for traffic with a parallel concern to economic and equity issues.

6.0 Applications and results

6.1 Introduction of Parking Pricing and Parking Restrictions in Athens

As had been suggested earlier, arbitrary parking is one of the major contributors to traffic congestion. The authorities lack a comprehensive policy towards parking management and thus, illegal parking is considered as a "status quo" within the city centre. The need for parking pricing is essential for Athens. The implementation of similar policies in other sites has shown that parking pricing could achieve an important reduction of traffic within the city centres. The introduction of parking pricing in Amsterdam resulted a 3% reduction in the number of car kilometres within the last decade (SAVE Action, 1998c, p.16). Furthermore, parking pricing can support the shift from private to public transport modes. As has been studied in Helsinki (European Local Transport Information Service, 2001), the implementation of parking pricing not only managed to restrict traffic volumes in the city, but also increased the share of public transport within the centre to a level of 60-70%.

Considering the fact that a few years ago, for a short period[16] the implementation of parking pricing in Athens resulted in a significant improvement in parking and traffic conditions (SAVE Action, 1998b), it becomes apparent that parking pricing, along with parking restrictions can play an important role as a transport policy instrument, towards the reduction

[15] Car sharing system in Berlin is presented in detail in the following chapter
[16] The application of the scheme has been finally postponed, due to jurisdictional and legal problems

of traffic within the city centre. However, before this can happen, jurisdictional issues have to be settled, as does the formulation of a comprehensive legislative framework to support the operation of the scheme.

6.2 Introduction of Road Pricing in Athens

According to a recent evaluation of demand oriented transport policies from SAVE Action (1998b, p.9), although parking pricing can contribute positively to the shift to public transport, it has only a low direct impact on traffic congestion. Thus, the implementation of more radical measures, such as road pricing, are needed in Athens in order to reduce traffic congestion and achieve a better modal share for public transport.

The Transprice project (Eurotrans Consulting Ltd, 1999) indicated that a future operation of road pricing scheme in Athens would be able to shift 5-6% of car users to public transport and a total of 25% of all car users to park & ride facilities. Furthermore, for a charge level of 1-3 Euros, a reduction of 40-50% could be achieved in the number of private cars entering the inner city cordon, as well as a 5-20% reduction in total vehicle kilometres. Thus, there is a strong indication that road pricing could produce excellent results in Athens.

Considering the fact, that the Transprice results are based only on modelling and demonstration (on small sample) assessments, the successful experience of Singapore can also be used to confirm the significant decrease of traffic flow[17] towards the city centre, as well as a major increase in average speeds[18] for all vehicles within the city centre.

Where?

As both the Transprice and Singapore experiences showed, road pricing on the city cordon is more efficient than any other road-pricing scheme. Taking into consideration that the inner city cordon in Athens already exists and its boundaries are clear to all drivers, road pricing would be much more feasible if implemented to the inner city area. After all, as it has been showed earlier, the major congestion problems in Athens occur within the city centre and therefore the implementation of the road-pricing scheme on the boundaries of the city inner cordon would be much more effective than anywhere else. On the other hand, there is a risk of a relative increase of traffic congestion outside the city cordon, on surrounding streets. This claim is probably exaggerated, as most of the computer models assume that total volume of traffic is fixed and switches from one road to another (SAVE Action, 1998c, p.7) instead of reducing in total. However, as the Singapore case indicated, a slight increase of traffic outside the city centre is inevitable. Considering the fact that a city cordon restriction already occurs in Athens, a future replacement of the restriction measures with a road pricing scheme, wouldn't bring major changes to traffic volumes outside the city cordon.

Further expansion of the road-pricing scheme to the outer circle can also be considered, but as Transprice indicated, the benefits are expected to be much lower than those of the inner city cordon.

How?

Electronic pricing seems to be the most advanced system for such an implementation. The comparative advantages of electronic pricing when compared to other systems (tolls, paper

[17] The traffic flow towards the city centre found to be 47% lower in Singapore after ALS and 15% after ERP

[18] Average speeds increased from 18 to 35km/h within the city centre of Singapore after road pricing

licences) are user convenience, high price adjustability and applicability to any road system. On the other hand, although the operational costs of the system are not very high, the implementation of the scheme requires a considerable initial investment, mainly due to the high cost of the gentries and the in-vehicle electronic units. However, all capital costs can be covered from the revenues arising from the operation of the scheme. In support of the latter claim, it is worth noting, that the net operational revenues in Singapore were enough to recover all implementation costs, within the first two years of the scheme (Gomez-Ibanez, 1994, p.14).

Road pricing could also be assisted by park & ride facilities, which promote intramodal transportation. Considering the fact that only 2% of the daily travellers use to commute through park & ride (Athens Urban Transport Organisation, 1998b), there is a great room for improvement towards this feature. As can be seen form the results of Transprice project (Eurotrans Consulting Ltd, 1999), car drivers in Athens would be more likely to shift to park & ride[19] rather than public transport modes after a road pricing implementation. Apart form the convenience of park & ride; the psychological dependence of car owners to driving might also be an explanation for this preference. In any case, park & ride could be an attractive alternative, especially if it parking places could be constructed near to metro stations or basic bus terminals.

6.3 Improvement of Public Transport Services

Along with the pricing measures and restrictions, supply oriented measures are needed in order to establish an attractive alternative for commuters. This could be done mainly through the improvement of the public transport system, which seems to be rather unsatisfactory according to the citizens of Athens. After all, the operation of a qualitative public transport system is not only a mechanism to attract people from other modes, but also a fundamental principle of sustainable transportation.

Improvements to the public sector in Athens should set as the major objective the increase of the network capacity and a better quality of services. The quality of the services in public transportation is a broad issue that can be defined in several ways and hence, many definitions have been found in literature (SAVE Action, 1998b, Franzen, 1999 and Newman & Kenworthy, 1999). Some elements are however, common in all definitions, such as regularity, reliability, convenience, less delays in traffic, quality of the shelters at bus stops, and finally static information material at stops.

The successful experience of Curitiba (Miller, 1999, p.736) indicates how sustainable transportation can be achieved through the operation of a well-designed public transport system. The introduction of land use practices, along with a sophisticated transport system which applied bus priority on the main “corridors” to the city, resulted in a total decrease of 30% in traffic during the past 25 years, even though the population almost doubled in the same period. Additional evidence of sustainability in Curitiba was the 25% lower gasoline consumption per person and the lowest outdoor air pollution rates among eight comparable Brazilian cities.

[19] According to Transprice project, 25% of the car drivers were eager to shift to Park & Ride, whereas only 5% of them preferred to shift to Public Transport

6.3.1 Bus lanes and Bus priority

One of the major problems of public transport is the unreliability of the schedules and the low average speeds of the buses. According to Athens Urban Transport Organisation (1998b), the average speed of buses is more than twice as low as that of private cars in the city centre. As it can be seen in table 6.1, the average speed of a bus drops down to 5-7 km/h during peak hours in the centre.

Table 6.1: Comparison of average speeds between private car and bus (OASA, 1998b)

	Entire Network	City Centre	City Centre - Peak hours
Private Car	35 km/h	23 km/h	11 km/h
Bus	17 km/h	10 km/h	5-7 km/h

A major instrument for improving the speed and thus the reliability of public transport is the implementation of bus lanes throughout the road network. The recent implementations of bus lanes in some rare cases in Athens have been mostly successful. According to SAVE Action (1998c, p.50) the operation of 13 bus lanes of a 12.5 km total length[20] resulted in an average increase of 10-60% of bus speeds. Furthermore, the average speed was found to be 60-100% higher during the peak hours. In streets where bus lanes have been implemented, private cars speeds decreased by approximately 10%, but part of this decrease may be due to the general deterioration on traffic conditions. Hence, a widespread implementation of bus lanes in the major arterial roads of Athens could significantly increase bus speeds and the reliability of the schedules. Bus priority could also be enhanced by a traffic control system which would give priority to buses at traffic lights or crossroads.

6.3.2 Technological innovation

The contribution of technology could also be essential for public transport. Implementation of telematics and information technology are capable of improving flow control. Moreover, an introduction of a smart card payment system could provide the basis for multi-purpose use of bus tickets to more than one, modes and furthermore prevent from a “free-ride” effect[21]. Dynamic information services could also provide real time information material on predicted arrival and departure times, as well as information to commuters about any incidents (demonstrations, traffic jams) that might cause them disturbances and delays in their travel.

A major technological improvement would also be possible with the gradual replacement of diesel buses with natural gas buses. To that end, Athens Urban Transport Organisation has already proceeded upon the procurement of 295 CNG (natural gas) buses, which is due to be accomplished in 2001. According to OASA (2001) the major advantages of CNG buses are:

- Less noise emissions and vibrations
- 65% - 80% lower emissions

Lenner (1993, p.205) points out that regarding NO_x emissions, CNG buses generate only 0.3 grams / person-km, whereas diesel buses produce 0.9 grams / person-kilometre (figure 6.1). Thus, it becomes apparent that CNG buses can contribute relatively more towards better air quality than conventional buses.

[20] Bus lanes are currently cover only 1,2% of the total road network that is used from Public Transport
[21] OASA (1998) estimates that 12% of the passengers evade ticket charges

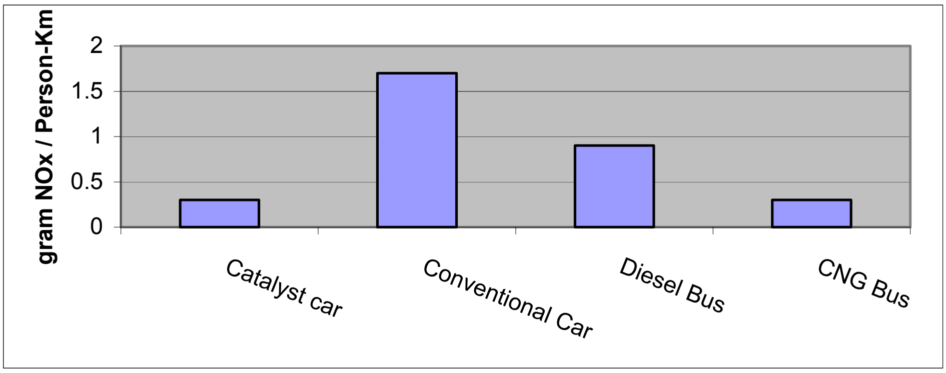


Figure 6.1: NO_X emissions per personal km, for different traffic modes
Source: Lenner (1993)

However, improvements of public transport require a considerable initial capital. The recent purchase of the 295 CNG buses required an investment of 52.4 billion drachmas (154 million Euro). Furthermore, the cost of a comprehensive telematics system for all buses of OASA (2001) has been estimated by the aforementioned agent at 27 billion drachmas (80 million Euro). Thus, finding sufficient funds for the improvements is a principal task facing the transport authorities.

6.4 Car Sharing

Considering the fact that the average occupancy rate of a private car is approximately 1.3 persons/car, car sharing would appear to be an attractive scheme in order to reduce traffic congestion. The major objective of car sharing is to reduce the number of cars on the streets and to achieve a more efficient use of each car. Whereas private cars may remain unused for long periods, a shared car is available immediately to the next person who needs it.

Successful implementation of car sharing programme has recently been achieved in Berlin. According to SAVE Action (1998a, p.24), a car pool of 180 vehicles has been established in Berlin, with 3,600 people participating in the programme. Each car travelled 34,000km per year, whereas an average German car travels only 14,500km per year. Regarding the demand for transportation, users of car sharing travelled an average annual mileage of 4,000km per person, unlike ordinary car owners who commuted an average of 8,700km per person. The average occupancy for shared cars was 2 persons/vehicle, whereas the average occupancy of a car in Germany is 1.3 persons/vehicle. Moreover, an overall analysis of the results showed that each shared car replaced 5 private cars, and saved approximately 42,000km per year.

In the case of Athens, car sharing would probably demonstrate cumulative benefits, due to the combination with the road pricing and parking restriction schemes. An exemption for high occupancy vehicles from road charges, or the supplying of parking places particularly for car pool-vehicles within the city centre, would subsidise car sharing initiatives and it would provide an additional intensive to car users to shift to car-pooling. Furthermore, the past experience of Singapore case indicated that car pools increased 53% after the implementation of road pricing (Gomez-Ibanez and Small, 1994, p.15). According to ICARO programme (Trias S.A, 2000), car sharing can also be co-operated with public transport. ICARO points to the example of Leeds city, where high occupancy vehicle lines have been established for both buses and cars of more than two passengers. Furthermore, ICARO suggests that car poolers could also be provided with discounts in bus fares, in cases where their trip back home is not assured by car pool.

In conclusion, car sharing can provide significant benefits towards the efficiency of transport networks, especially when used as a supplementary measure to demand oriented policies. Particularly in Athens, car-sharing -along with public transport- could provide major assistance towards the success of road pricing, by offering a convenient and attractive alternative to car users.

6.5 Financing the schemes and utilising the revenues

A major issue for any fiscal measurement is the collection and redistribution of the revenues. As Husock (1999) claimed, the overall success of any road-pricing scheme is actually dependent upon the use of the revenues. As mentioned in an earlier stage, the implementation of an electronic pricing system requires high initial capital and furthermore, a considerable cost in terms of operational expenses. Thus, a part of the revenues has to be used to cover these costs. Moreover, in order to prevent equity issues which might arise with the introduction of pricing measures, an efficient rearrangement of the revenues has to be carried out. The most favourable technique among governments in that direction is the re-investment of the revenues either in road infrastructure, or in public service improvements.

Theoretically speaking, infrastructure improvements can only provide satisfactory solutions in the short-run. It is widely acknowledged among academics that any infrastructure improvements can improve traffic conditions only for short periods of time. As professor Papaioannou (1999) indicates, "*a higher level of infrastructure supply will result to an increase of demand and finally the transport system will reach a new equilibrium point at a higher level*". Taking into account that due to the following organisation of the Olympic Games, the Greek government has already embarked upon an extensive infrastructure improvement of the road network, the need for improvements in public transport service becomes more apparent. After all, as it can be concluded from the former analysis of the problem, the authorities –although indirectly- have subsidised car driving over the last two decades to the detriment of the public sector and thus there should be an ethical commitment for the formulation of an efficient and viable public transport system.

The relevant experience of other cities that have implemented road pricing, shows a variety of different uses of the revenues. According to Ramjerdi (1995) the authorities in Oslo, used 20% of the revenues to improve public transport services and 80% of them to maintain the road network. In case of Oslo though, the major policy goal was to achieve infrastructure improvements and thus, road pricing has been implemented mainly to raise revenues to that direction. Moreover, revenues from toll pricing were relatively lower compared to the total revenues from car use and car ownership taxes[22], and thus they were not considered as a major source to raise funds towards all transport investments. Taking as a given, that the major objective for the transport system in Athens is not infrastructure improvements but a decrease in traffic congestion, a high percentage of the revenues could be used to support public transport improvements.

An interesting issue to be investigated is how much it would cost to implement road pricing in Athens, and furthermore, the level of revenues could be expected. Such an analysis, would only be viable with an extensive financial investigation, mainly because of the numerous parameters which would have to be considered. However, relative studies can point out the

[22] According to Ramjerdi (1995), Toll revenues were 1.5 billion NOK, whereas revenues from other "car driving-oriented" taxes were 30 billion NOK, (in 1995)

corresponding costs and revenues of similar road pricing schemes. In Table 6.2 illustrates different levels of costs and revenues among conventional road pricing schemes. As can be seen in the following table, the revenues in all cases were high enough to cover the initial investments for the schemes.

Table 6.2: Summary of costs and revenues for Road Pricing schemes, in million US$ (Gomez- Ibanez and Small, 1994)

	Capital cost	Annual Operational cost	Annual Revenues
Singapore (ALS)[23]	2.7	0.3	2.7
Bergen (tolls)	2.0	1.6	10.1
Oslo (tolls)	41.6	11.2	96.0
Trondheim (tolls)	7.2	1.15	11.3

However an electronic pricing system, is relatively more expensive in terms of capital outlays. The implementation cost of the Electronic Road Pricing (ERP) scheme in Singapore reached the level of 125 million US dollars (Willoughby, 2000), which is undoubtedly higher than any conventional road-pricing scheme. Nevertheless, as Husock (1999) claimed, although the capital cost of such a scheme is rather high, it is still relatively low when compared with road expansion projects. Furthermore, due to the technological advantage of the system, operational costs estimated to be much lower than in any toll or area licensing scheme.

6.6 An estimation of the revenues

It has been already discussed that the potential improvements of the public transport system, such as introduction of telematics, integrated fare systems, bus lanes, and modernization of the bus fleet, require a considerably high level of financing. At the same time, according to OASA (2000, p.99), the revenues from the ticket sales cannot cover more than 38% of the annual net operational costs[24] of the public transport system. An overview of the finances of the public transport sector (OASA) is illustrated in table 6.3.

Table 6.3: Financial statement of OASA for the year 1997, in million Euros (OASA, 2000)

Operational Costs & interests	Annual Investments	Annual Subsidy from the State	Loans to cover the annual Shortage	Revenues from Ticket Sales
419	35	117 (25.7%)	226 (49.7%)	111 (24.5%)

Table 6.3 indicates a great annual shortage in the budget of OASA and hence, no major investments towards the improvement of public transport services could be funded from internal resources. Hence, the major question on that point is weather or not the revenues from a potential implementation of a road pricing scheme would be enough to close the financial gap of the public transport and subsidise the improvements. Although a precise calculation of the revenues requires a consideration of numerous variables, a rough estimation will be attempted. However, it should be noted that the following estimations do not refer to any scientific method, and a lot of factors are assumed in favour of the simplicity of the calculations. Moreover, in a real world, transportation systems are dynamic and therefore the results are strongly connected to the fluctuations of the different values.

[23] The data refers to Area Licence System which introduced in 1974
[24] Interest costs are not considered

Knowing that approximately 300.000 cars enter the city cordon on a daily basis (Athens Urban Transport Organisation, 1998) two scenarios will be investigated. Scenario A will be the weak one, where a decrease of only 20% of private cars entering the city cordon will be assumed, due to the latest results of ERP in Singapore (Husock, 1999). Considering the Transprice estimations (-40% to -50%) for Athens and the results of the initial road pricing scheme in Singapore (ALS, -47%), the strong scenario (Scenario B) will assume a 40% decrease in the number of cars entering the city cordon. The mean charge value of 2 Euros will be used for both cases, with regard to the values that have been used at Transprice (1-3 Euro) for cordon charging. Furthermore, excluding Sundays and holidays, an implementation of the road pricing for 300 days per year will be envisaged. The particular characteristics of the two scenarios are:

Scenario A - Weak scenario

- 300,000 cars entering the inner city cordon before road pricing
- 210,000 cars entering the inner city cordon after road pricing (20% decrease)
- Price fixed at: 2 Euros for each vehicle entry
- Road pricing implementation for 300 days per year

Scenario B – Strong Scenario

- 300,000 cars entering the inner city cordon before road pricing
- 165,000 cars entering the inner city cordon after road pricing (40% decrease)
- Price fixed at: 2 Euros for each vehicle entry
- Road pricing implementation for 300 days per year

The results of the calculations can be seen in the following table (6.4), along with a rough estimation of the costs:

Table 6.4: A summary of the annual estimated costs and revenues from a potential ERP implementation in Athens

Capital Outlay[25]	Operational Costs[26]	Revenues - Scenario A	Revenues - Scenario B
136 million Euro	10-13 million Euro	128 million Euro	100 million Euro

Table 6.4 indicates that the expected revenues are enough to recover the initial investment of the scheme within the first two years of the implementation. Furthermore, 10% of the annual revenues are enough to cover the operational costs of the scheme. It becomes apparent that the size of the revenue is not large enough to cover the shortage in the public sector. However, a 50%-50% distribution of the road pricing revenues to public transport subsidies and to the paying off of the scheme, would allow:

1. A recovery of the initial capital investment within 3 (scenario A)– 4 years (scenario B)
2. The annual operational costs to be covered
3. An increase in the annual budget for public transport investments (see table 6.3) from 35 million Euros to 99 millions (+ 182%) in scenario A, or to 85 millions (+142%) in scenario B.

Moreover, due to the modal shift towards the public transport modes (approximately 5% according to Transprice), an increase in revenues from the ticket sales could also be achieved

[25] The capital cost of ERP in Singapore has been used as a reference to estimate the relative cost in Athens
[26] According to all previous road pricing cases (figure 6.2), operational costs usually absorb 10% of the revenues

for OASA. Consequently, improvements such as the introduction of higher technologies and the operation of bus lanes could, without doubt, be financed from the revenues that will arrive.

Most importantly, a decrease of traffic congestion within the city centre will improve the atmospheric quality, due to lower emissions. An estimation of the emission reductions from road pricing is also an issue of a great interest, but it is beyond the scope of this paper[27].

7.0 Discussions

7.1 The issue of Political and Public Acceptability

An important issue for the implementation of any policy measure is the public acceptability. No matter whether or not a policy is able to guarantee successful results, there is no chance of successful implementation in practice if public acceptability is not adequate. A major factor influencing public acceptability is the level of awareness among the public for traffic and environmental problems of the city. In case of Athens, a recent opinion poll showed that Athenians are in principle aware of the congestion problem. According to Eleftherotipia (2001), 88% of the people in the survey replied that they would be eager to accept car restrictions in favour of a better urban environment. Furthermore, when their opinion about the “A day in the city without my car”[28] project was asked, most of them responded that they would like to see more often initiatives of that nature. Figures 7.1 and 7.2 show the responses of the people to the major two questions:

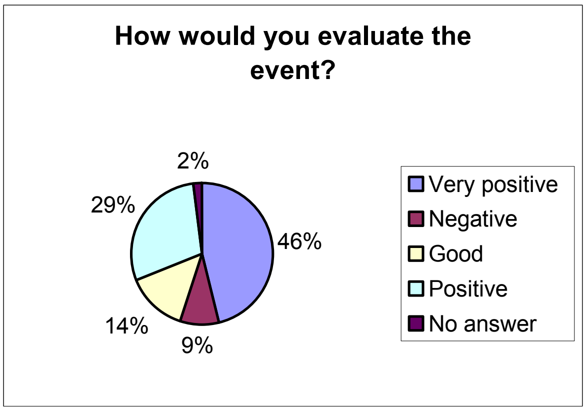


Figure 7.1: Results of the opinion poll
Source: Eleftherotipia daily newspaper, 2001

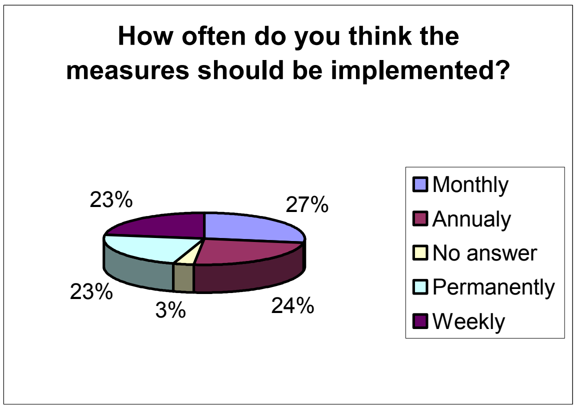


Figure 7.2: Results of the opinion poll
Source: Eleftherotipia daily newspaper, 2001

On the other hand, as Transprice project (Eurotrans Consulting Ltd, 1999)has also indicated, public and politicians are in general loath to accept pricing measures. Hence, the option of implementing fiscal measures in Athens is a very “sensitive” issue, since the initial response from the people might be negative. Successful implementation of road pricing requires an intensive process of informing of the public about the effectiveness of the scheme as well as a series of additional measures which would clarify that road pricing will not operate as a

[27] An interesting method for such a survey has been found in the CORINAIR project (2001)
[28] “A day in the city without my car” is a European initiative, which takes place every 22nd of September in several European cities as an absolute car restriction scheme within the city centres.

governmental "milk-cow" policy (Hansson, 2001). To that end, it is important to accompany the fiscal measures with supply-oriented measures, in order to formulate a comprehensive and balanced policy package which will "push and pull" people's transport behaviour.

7.2 Jurisdictional problems

Administrative organisation in Athens, along with the corresponding jurisdictions and responsibilities of the various administrative bodies relevant to urban and transportation planning in the broader area, is rather complicated. There are 83 local authorities, 4 second level bodies (3 Prefectures and 1 Union of Municipalities), the Athens Structure Plan Organisation, the Athens Urban Transport Organisation, and a number of other bodies with jurisdiction limited to more specific subjects introduced indecision making. Above all, there are at least 5 ministries (Transport, Environment, Culture, Public Order and Development), which define the policies relevant to urban and transport development and initiate or subsidise all public works. Moreover, for any fiscal measurements implemented, official approval from Ministry of Economics is required. Thus, decision-making is rather a complex and slow procedure, due to the numerous bodies that have to agree on any potential policy or measure.

It is evident that the current distribution of jurisdiction among the authorities is not able to provide an adequate institutional framework towards transport management in the capital. Therefore, there is a need for a metropolitan transport agency, which will be authorised to design, develop and operate transportation in Athens, without major interferences from other authorities. The paradigm of other European capital cities, such as Amsterdam (SAVE Action, 1998c, p.54), where sole municipal bodies are completely responsible for urban transportation, represents a good example for the Greek authorities. However, particularly in Athens, due to its considerably large concentration of technical and political experts, Athens Urban Transport Organisation is probably the most suitable organisation to take up such a challenge.

7.3 Is Sustainable transportation an obstacle for economic growth?

As discussed before in the theory, economic objectives of sustainable transportation are the most controversial. An important question for the implementation of road pricing in Athens could be whether or not reverse impacts could arise for the economy. The truth is that in principle, fiscal measurements have negative impacts on consumption trends and thus for the economy as well. Road pricing is by definition, a direct taxation on car driving, and as such it aims to reduce traffic. A potential decrease of car driving would certainly reduce fuel consumption and thus it would probably affect the fuel market as well. Consequently, such a significant decrease of fuel consumption would touch the economic interests of the fuel business. At the same time, commercial activity within the city centre could also be questioned, although the Singapore experience showed no side effects on the business sector after the implementation of the scheme. In conclusion, regarding the short-run economic effects, there is considerable opposition to road pricing and thus, all economic parameters should be considered before the introduction of any fiscal measurement.

However, as has already been claimed, the fundamental principle of sustainability is that it lies in a future horizon. Considering the long-run effects of sustainable transportation, it should be stated that sustainable transportation is more likely to boost urban economies in the future. A recent study from the World Bank (2001) indicated that cities with a substantial commitment to sustainable transportation are doing better economically. To support this claim, the study refers to the cities of Munich, Zurich, Tokyo and Paris, where as well as wealth, they are benefiting from sustainable transport systems. Moreover, sustainable transport systems can reduce externalities and thus economic costs in the future. Hence, direct economic benefits can also arise due to an enhanced environment, which attract commercial investments and people.

Finally, the latter claim also turns to be an issue of political and public acceptability, due to the fact that is it probably uncertain whether or not both governments and citizens are eager to afford additional weights, in favour of any future benefits.

8.0 Conclusions

This study sought to investigate weather or not the current passenger transport system in Athens fulfils the fundamental principles of sustainable transportation and which problems might occur. To that direction it has been found that:

1. The current passenger transportation system in Athens does not meet most of the requirements for sustainable transportation
2. The major problem of traffic congestion occurs mainly within the city centre, due to the large number of private cars
3. Traffic congestion has a severe impact on the operation and competitiveness of public transport modes

Furthermore, an analysis of the possibilities towards sustainable transportation in Athens has been attempted. The most important findings are that:

1. Road pricing can be an essential policy instrument to reduce congestion and shift commuters to alternative transport modes, particularly in Athens
2. Road pricing can generate a considerable amount of revenues, which would be enough to sustain the operation of the scheme as well as to subsidise investments in public transport
3. Reinvestment of road pricing revenues towards the improvement of public transport, could present accumulative benefits in support of a sustainable transport system, especially when combined with policies such as parking restrictions and car sharing.
4. Although a road pricing scheme is practically feasible in Athens, political and public acceptability constitute a major obstacle to the actual implementation.

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