EVALUATION OF TRANSPORT POLICIES IN ATHENS

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1. ABSTRACT

An evaluation of policies that could improve traffic and environmental conditions and reduce energy consumption in the city of Athens is presented. The analysis is carried out with the aid of a Decision Support System (DSS) integrated in a Geographical Information System (GIS). Six policies (area restriction for private cars, toll imposing, parking restrictions, bus-lanes, introduction of new fuel technologies for public transport vehicles and fuel taxation) are examined. The policies are evaluated according to their performance for a number of traffic, accessibility, energy and environmental indicators and to their benefits with respect to a Reference State. The results demonstrate that fuel taxation, area traffic restriction and parking restriction have substantial benefits, especially when applied in a large area.

2. INTRODUCTION

Among the sectors of society that use energy and pollute the environment, transport stands out for two main reasons. First, transport accounts currently for about 25% of global energy consumption. Second, in contrast with other sectors, emissions from transport are on the rise, due to the continuously growing demand for transport (van Wee et al., 1998). Emissions include global pollutants (such as CO_2), national or regional pollutants (such as NO_X) and local pollutants, such as particulates (Stead, 1999). Figure 1 illustrates these trends. The Common Transport Policy adopted by the European Union "aims to promote efficient and sustainable transport systems that meet the needs of both citizens and business, taking into account environmental impacts". One of the instruments that may divert transport developments towards a more sustainable transport system is to promote policies that would enhance the role of public transport as an alternative of private modes (Goodwin, 1999).

There are several strategies for the management of traffic and transport problems. Three major categories of policies can be defined: demand-oriented, supply-oriented and technology policies. The instruments that may control transport demand are regulation (restrictions of road use) and economic disincentives (road pricing). Supply-oriented measures attempt to make public transport more attractive whereas technology instruments aim to improve energy consumption and emissions.

The present work examines policies that belong to all three strategies, in contrast to past efforts in this field that focus in a single policy or similar, non-diversified policies. A number of indicators is used to quantify the results of the analysis, which are obtained by a Decision Support Tool integrated in a Geographical Information System (GIS).

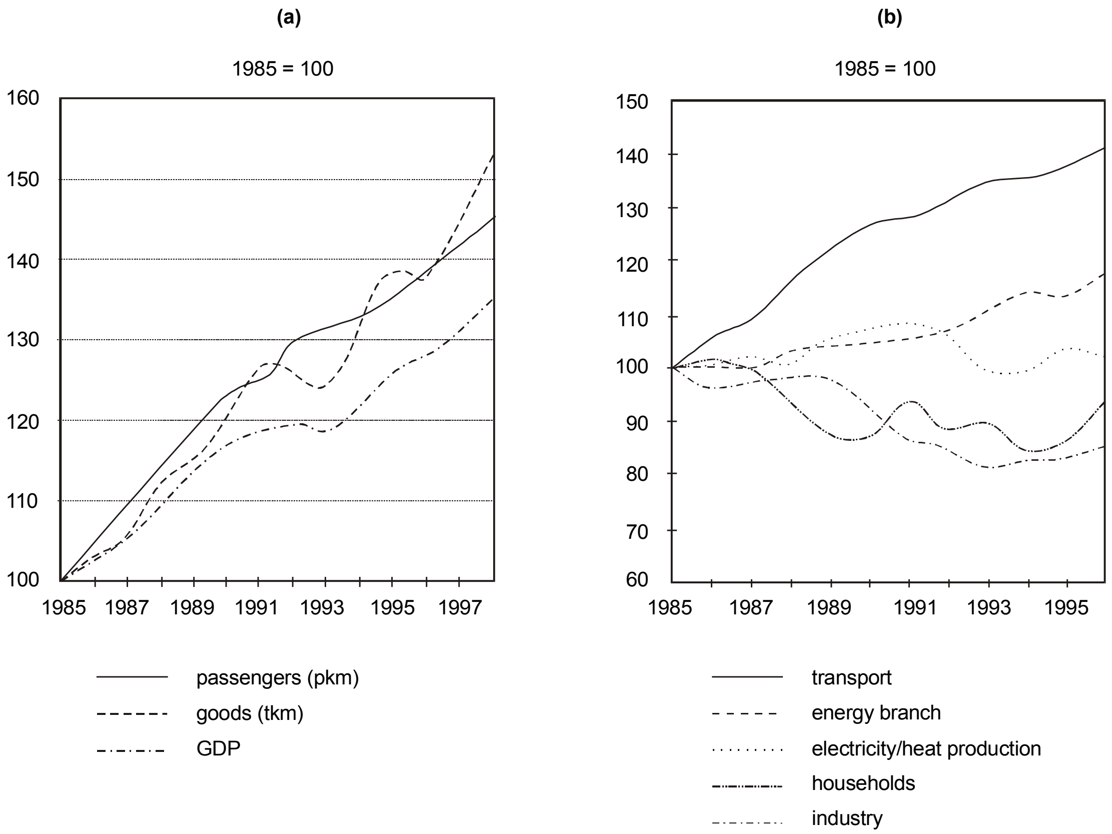

Figure 1 (a) Trends in demand for transport, (b) Trends in CO_2 emission by sector in EU15, (European Union, 2000)

3. THE TRANSPORT NETWORK AND THE TRAFFIC PROBLEMS OF ATHENS

The transport infrastructure in Athens consists of a road network with a total length of 8,000 km. The main road network covers 1,826 km. The centre of the city is the area bounded by the inner ring road (an area of 9.2 km^2). There is also a (middle) ring road system surrounding an area of 111 km^2.

All road traffic in Athens (private as well as public modes) involves significant traffic delays and low traffic speeds. As a result of the increase in travel demand and the rapid increase in the use of private cars during the last 25 years, there is currently a 2.6% average annual increase of traffic within the central area. It has been estimated that 13.5% of the roads that lead to signalised intersections in Athens are saturated; for the central area this percentage rises to more than 22%. More than half of the trips are made by motorised private modes and mainly by private car (44%). Athens has by far the largest share of trips made by taxi in E.U. (6%) and an above-average share for public transport use (32%) (Athens Urban Transportation Organization, 2000).

High-level concentrations of primary pollutants such as CO and photochemical pollutants such as NO_X and O_3, are frequently observed. The transport sector contributes greatly to this, being responsible for black smoke, nitrogen oxides, carbon monoxide and hydrocarbons emissions. Private cars are responsible for more than half the pollution caused by all transport modes. The use of catalytic-technology cars and the gradual replacement of the conventional ones contributed to an average decrease of 25%-40% of air pollution in the 1992-2000 period.

4. EVALUATION PROCEDURE

The most important policies that match the Athens transport profile were selected for analysis: area restriction for private cars, toll imposing and parking restrictions (demand-oriented), bus-lanes (supply-oriented), introduction of CNG fuel technology for public transport vehicles and fuel taxation (technology).

The selection was made either for policies already implemented or considered for future implementation by local authorities (Apostolidis et al. 1998). Area restriction is used because of the need to relieve the city centre from the trips of private vehicles. Moreover, as there is a serious parking problem, parking restriction policy could be a method to handle this problem. Area pricing is an alternative policy and the use of bus lanes may improve the competitiveness of public transport modes and attract more passengers. The use of CNG buses could help in reducing pollutant emissions. Fuel taxation could reduce fuel consumption and shift passengers to public transport.

To assess the impacts of the examined policies, a number of suitable indicators were evaluated. Vehicle-kilometres and public transport average speeds were used for appropriately depicting traffic conditions; modal share of public transport for the transport level of service (accessibility). Energy consumption and external cost of air pollution were also considered as energy and environmental indicators. It is clear that the indicators are highly correlated, as a deterioration of traffic conditions directly causes environmental deterioration (European Environment Agency, 2000). The indicators were selected and defined in such a way as to facilitate the presentation and interpretation of policy impacts by experts, as well by authorities of a less technical background (Stead, 2001). For this purpose, all indicators are estimated as averages or totals over the entire study area, which are useful for quick comparison of policies and measures.

In the process of transport policy making there is a need for models to support the design and evaluation of policy measures. Traffic volumes and speeds are required throughout the transport network in order to estimate energy consumption and pollutant emissions. Unfortunately, the core problem of transport policy modelling – the simulation of traffic flows – is difficult to be solved. Against this background, an easy-to-use tool was developed, that both simulates traffic and analyses transport measures (Arampatzis et al. 2001). The tool is Decision-Support System (DSS) integrated into a Geographical Information System (GIS) that evaluates transport policies in terms of appropriate transport indicators, energy consumption, atmospheric emissions and external costs. The seamless integration of external costs in such analysis is novel. Next to GIS data handling functionalities and interfaces, the tool contains two calculation modules: the emission/consumption model and the traffic model (a deterministic model that solves the elastic user equilibrium assignment problem with capacity constraints). It also includes a module for policy definition, with several functionalities that help the user to interpret the results of the analysis.

5. EVALUATION OF POLICIES

The results obtained by the DSS under the conditions of the Reference State serve for comparison purposes as well as for assessing the effectiveness of different policy measures. The Reference State considers the Greater Athens Area (a region of 1,450 km^2) with no implemented policies. The reference state refers to a virtual situation where no restriction of even-odd plates applies for the center of the city nor bus-lane system has been introduced. The origin-destination matrix provided is for the morning peak hours of 1996.

For each policy, two scenarios are examined; a low intensity (or soft) scenario and a high intensity (or hard) scenario. A brief description of the selected scenarios is presented in Table 1. The meaning of soft scenarios is that they can be applied with minimum effort under current economic as well as social constraints. The soft scenarios are similar to those that are currently implemented in the city (i.e. examination of the implementation of area pricing to the same area that the area restriction scheme is applied today). Each scenario examines one policy separately. The objective is to show

how the implementation of one policy (with a predefined intensity) affects the Reference State. The results are portrayed in Figures 2-5.

Table 1 Selected scenarios

	Soft	*Hard*
Area Restriction	50% restriction of private car traffic within an area of 9.2 km^2	50% restriction of private car traffic within an area of 111 km^2
Parking Restriction	50% reduction of parking spaces within an area of 9.2 km^2	50% reduction of parking spaces within an area of 111 km^2
Area Pricing	Toll stations are placed in the entrance of an area of 9.2 km^2, with a toll of 1 Euro	Toll stations are placed in the entrance of an area of 111 km^2, with a toll of 1 Euro
Bus Lanes	Implementation of bus-lanes in 12 km of roads	Implementation of bus-lanes in 150 km of roads
CNG buses	Replace 65 thermal buses with CNG buses	Replace 298 thermal buses with CNG buses
Fuel Taxation	All private car drivers pay 0.1 Euro per travelled km	All private car drivers pay 0.5 Euro per travelled km

The comparison between policies such as area-traffic restrictions, parking restrictions, area pricing and fuel taxation could be easily performed due to the spatial homogeneity of these policies. For the first three policies, a low application scenario is considered in an area covering 0.6% of the entire area (inner ring area). The hard application scenario is applied to the entire area of the inner and middle Athens ring (an area covering 8% of the entire city).

Area-traffic and parking restriction policies have encouragingly positive impacts. The effect of the area restriction is more intense than the parking restrictions, as the former prohibits a percentage of all trips to enter the area, when the latter forbids only the trips, which have as destination the specific area (i.e. in the parking restriction scenario, trips through the area are allowed). As it was expected, positive effects of these policies are more significant in the “hard” implementation scenarios.

Area-pricing policy has a different result when it is compared to area restriction and parking restriction policies. As it is shown in Figure 3, modal share indicators are almost the same for the three policies in the “soft” cases (small application area). Public transport modal share for the area-pricing policy is 30.5%; this is slightly less than that of area-restriction policy (32%) and slightly more than that of parking-restriction policy (30%). However, when policies are applied to a larger area (“hard” scenarios), modal share indicator for area-pricing policy is low, compared to the other two policies (32.3% for area-pricing, 40.5% for area-restriction and 39.3% for parking restrictions). This indicates a very low marginal effect (the contribution to indicator made by a marginal increase of the application area).

Another important observation concerning the effects of area-pricing policy is that although public transport modal share increases, energy consumption and external cost indicators are practically not affected. This is more evident in the “soft” application case, where energy consumption is slightly raised and external cost is slightly decreased. This is in contrast with the results obtained under the area and parking restriction policies, where a significant reduction of energy consumption and external cost is observed. These indicators depend on the total vehicle-km travelled and the mean travel speed (increase with respect to vehicle-km raise and decrease with respect to speed raise). The total vehicle-kms travelled are not decreased, as it was expected, by the increase of public transport modal share when the area-pricing policy is applied (by 0.1% only with respect to the Reference State, compared to 7.2% and 6.3% of the area and parking-restriction policies, respectively). Moreover, the vehicle speeds (both for public transport and private cars) decrease with respect to the other two policies. This is due to the fact that tolls force drivers to follow alternative paths of longer distance outside the application area. This also leads to congestion outside the area and to the reduction of travel speeds. In the case of the “hard” scenario, speeds increase and the total vehicle-km travelled further decrease (almost 5% of the Reference State), since the implementation area is larger and the positive effects of this policy become dominant.

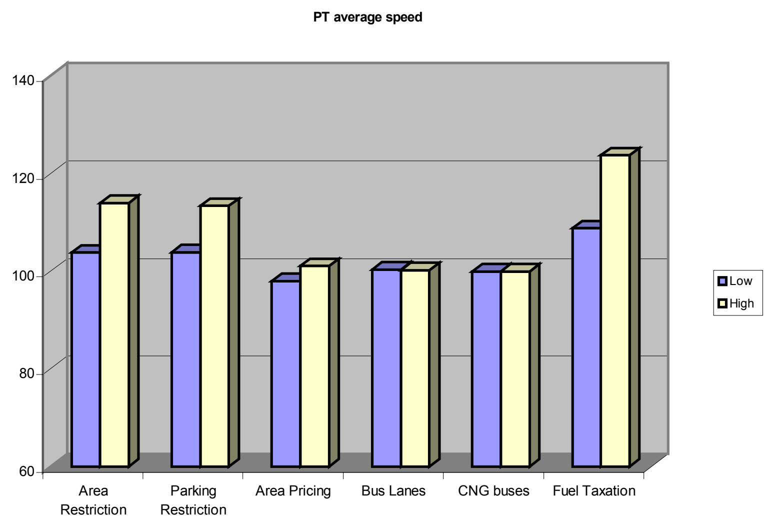

Figure 2 Public transport speeds for a “soft” and “hard” application of policies

Regarding the fuel-taxation policy (“soft” case), modal share is increased to 12.7% with respect to the Reference State (which is less than that of area restriction policy, 16.4%, and more than that of parking restriction policy, 8.8%). The decrease of energy consumption is larger (about 15%, compared to 9% for area restriction policy). This is due to the change of vehicle speeds and total vehicle-km travelled (travel speeds are bigger than in other scenarios, and vehicle-km travelled are less).

The fuel-taxation policy is implemented on the whole city area, whereas area, parking-restrictions and area-pricing policies are focused on a specific area. In the fuel-taxation policy there is no congested or favoured areas. As drivers practically pay an amount proportional to the travelled distances, they tend to choose the shortest route. The “hard” case of fuel taxation has the largest benefits of all other scenarios. This is due to the price of 0.5 Euro imposed per travelled km, which can be described as rather high.

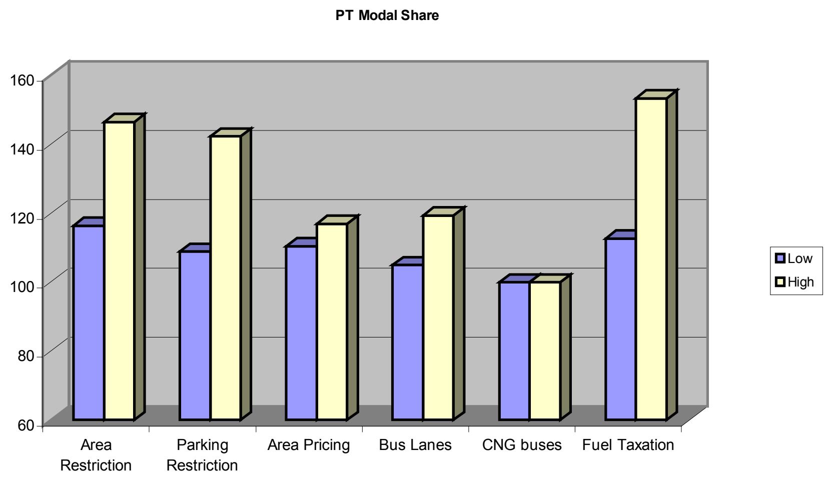

Figure 3 Modal share of public transport for a “soft” and “hard” application of policies

The use of CNG buses instead of thermal ones does not affect either traffic or accessibility indicators. It affects slightly energy consumption and has environmental benefits. It is a policy that works to the correct direction, but cannot stand on its own, as it does not solve the traffic and accessibility problems. CNG vehicles emit no particulates, smog and sulphur compounds, while emissions participating to photochemical pollution are reduced by 80%. Noise is also significantly lower. CNG fuel is stored in special tanks under pressure of 200 bars, a fact that may create an image of non-safety to the public. However, CNG vehicles are safer than vehicles operating with conventional fuels (Mpizas, 1998).

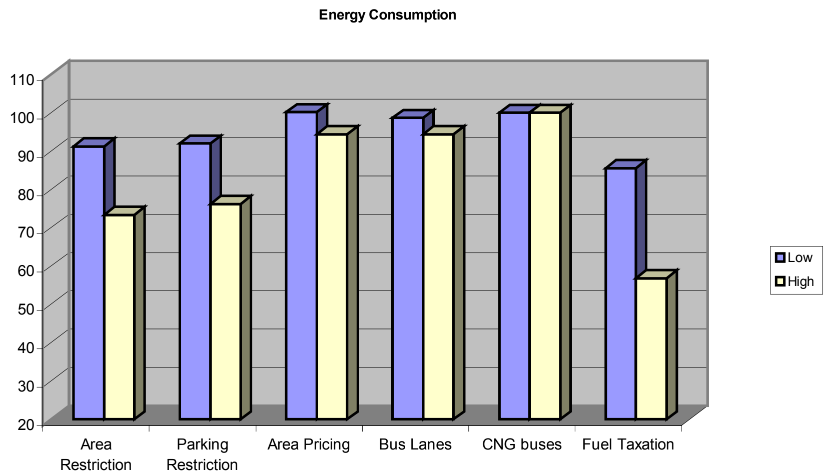

Figure 4 Energy consumption for a “soft” and “hard” application of policies

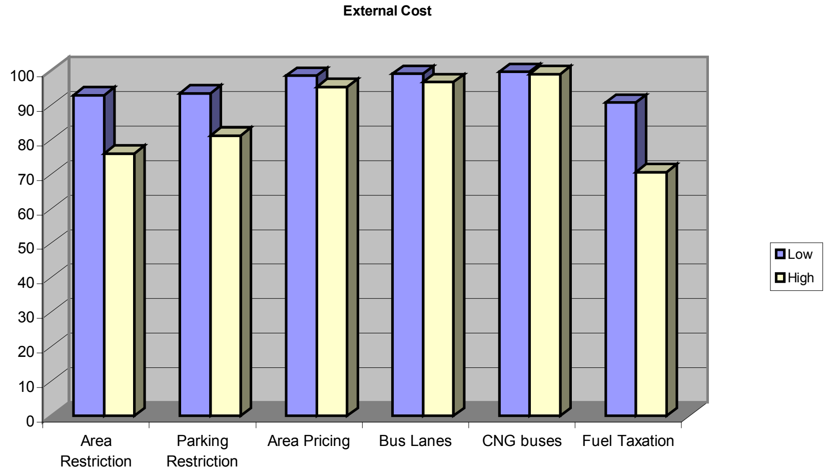

Figure 5 External costs for a "soft" and "hard" application of policies

Bus lanes increase the public transport speed on the roads that restriction is imposed. However, the effect on the entire area is comparatively small. Difference can be observed when restrictions are imposed in specific areas (such as major or radial arterial roads), where speeds of public transport are significantly small. Bus lanes also have some positive effect on public transport modal share, as the increase of Public Transport speed in strategic points, results in decreased travelling times and, therefore, improved public transport service. However, as private cars are excluded from using the specific lane of the road, the remaining space is not adequate and this could create congestion effects. As a result, drivers do not account bus lanes as a positive measure.

Table 2 summarises the effectiveness of each policy to each one of the four indicators. Fuel taxation, area traffic restriction and parking restriction policies favour significantly all four indicators, especially in the "hard" case scenarios. From these results, a list of policies can be constructed starting from more to less affective in respect to the four indicators. This list is presented in Table 3.

Table 2 Evaluation of policies

	Area Restriction		*Parking Restriction*		*Area Pricing*		*Bus Lanes*		*CNG buses*		*Fuel Taxation*	
Indicators	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard
Traffic	+	++	+	++	-	o	o	o	o	o	++	++
Accessibility	++	+++	+	+++	+	++	+	++	o	o	+	+++
Energy	+	++	+	++	o	+	o	+	o	o	++	+++
Environment	+	++	+	++	o	+	o	+	o	o	+	++

- *Low negative impact, o Practically no impact,* **+** *Low positive impact (low effectiveness),* **++** *Medium positive impact (medium effectiveness),* **+++** *Large positive impact (highly effective)*

Table 3 List of policies that favour indicators (more to less effectiveness)

Traffic	*Accessibility*	*Energy*	*Environment*
Fuel Taxation (H)	Fuel Taxation (H)	Fuel Taxation (H)	Fuel Taxation (H)
Area Restriction (H)	Area Restriction (H)	Area Restriction (H)	Area Restriction (H)
Parking Restriction (H)	Parking Restriction (H)	Parking Restriction (H)	Parking Restriction (H)
Fuel Taxation (S)	Bus Lanes (H)	Fuel Taxation (S)	Area Restriction (S)
Area Restriction (S)	Area Restriction (S)	Area Restriction (S)	Parking Restriction (S)
Parking Restriction (S)	Area Pricing (H)	Parking Restriction (S)	Fuel Taxation (S)
	Parking Restriction (S)	Area Pricing (H)	Area Pricing (H)
	Area Pricing (S)	Bus Lanes (H)	Bus Lanes (H)
	Fuel Taxation (S)		
	Bus Lanes (S)		

(H) Hard application scenario, (S) Soft application scenario

6. CONCLUSIONS

A number of policies that can improve the conditions of transportation in the Greater Athens Area have been analysed. The policies have been classified into three strategies (demand-oriented, supply-oriented and technology). Several indicators were used in order to facilitate the evaluation procedure made with a Decision Support Tool.

Fuel taxation, area traffic restriction and parking restriction have significant benefits. However, the possible discomfort they could cause to the affected people should be considered. A discomfort on the use of a private mode cannot, by its own, attract passengers to public transport modes. It should be accompanied by higher-level public transport services and should be used together with demand-oriented policies (such as bus-lanes). Area-pricing policies work efficiently with only a “hard” application scenario and in most cases exhibit significant benefits in all indicators.

It is very uncertain whether such strict policies could be applied on a permanent basis, due to their possible social disapproval (Harrington et al., 2001). The social feasibility of policy measures is a parameter that needs to be taken into consideration (Rienstra et al., 1999).

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