

Analysis of transport modes in the urban environment: an application for a sustainable mobility system

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Abstract

The paper intends to analyze transport modes in the urban environment, confronting the experience in different settings, urban and suburban, in cities of different sizes. The process introduced aims to improve the quality of life and access for more sustainable patterns of development, while at the same time not harming the urban mobility, proposing a model that can be applied to the different urban areas. The high costs of construction of additional road space, and the consideration that a greater offer of road space is an impulse for a greater demand of private car traffic, leads the planning process in the direction of using existing road space more efficiently, by using traffic control mechanisms, and shifting demand to alternative modes. The spreading of heavy traffic using unsuitable roads has led to the increase of the risks for public health and safety, being the levels of pollution to be dangerously high and the pedestrian mobility to be strongly restricted. The actions discussed in the paper are parking policies, which aim to redistribute on and off road parking, discouraging parking in what is the central area by means of charging policies and the institution of Controlled Traffic Zones, and by doing so shifting long term parking to fringe areas. A key factor of the success of the proposed parking policy is the institution of pedestrian routes promoting walking and cycling. The planning of the Transport System includes a mix of measures designed to encourage people to use public transport (“pull” measures) and, where appropriate, measures to reduce the use of private cars (“push” measures). Push-measures can be divided into financial instruments, and technical and regulatory constraints. In the paper an application to study areas is presented, describing the scenario before the adoption of the proposed policies, and after the application at the date, presenting some results in comparison. The government of cities requires a policy for traffic management, and thus it implies, among the other traffic control strategies, adequate parking policies. Traffic and transport related activities and infrastructures can affect users and non users of the system alike, as in the case of the occupation of public spaces, accidents, noise and air pollution, and congestion of the road network (i.e. transport externalities).

Keywords: traffic, environment, parking, pedestrian.



1 Introduction

Traffic pollution in urban areas is part of a wider range of effects that the road network has on the environment.

The quality of life in the city environment can, in fact, be considered as the result of the actions of a series of factors that take part, directly or indirectly, in forming the characteristics of the ecosystem and living conditions, which define the sustainability of the urbanised area.

The planning and management choices for the transports system, and the eventual realization of new infrastructures (interchanges, park and ride facilities, cycling and/or pedestrian routes, etc.) are expected to achieve a substantial improvement of the characteristics of the system's effectiveness, and at the same time to achieve benefits for the environment.

It is necessary to assess the strategic choices adopting suitable models of analysis which, with reference to the non-intervention hypothesis (option zero), allows to determine impacts, positive and negative, defining the alternative, among the possible ones, which maximise the utility of each different action proposed for the system.

The option proposed regards the influence which opportune parking management policies have on the transport system, defining a suitable strategy for the improvement of the running conditions of the network.

2 Transport externalities

Traffic externalities produce negative effects on the community. In its definition externality is what is had when a subject's objective function contains a variable which depends on the behaviour of another subject, whose decisions do not hold account of the first.

In economy externalities mark a failure of the market. The prices do not reflect the entire social cost and it becomes necessary to estimate the part of not calculated social cost. In the public sector, the administrator can adopt actions to correct the effects of externalities as:

- 1) tolls and taxes;
- 2) regulations and restrictions to limit and to reduce the causes of externalities;
- 3) subsidies to promote alternative and/or corrective actions.

The introduction of taxes or subsidies corrects the externalities since it equals the private marginal cost to the social marginal cost and equals the private marginal benefit to the social marginal benefit.

Taxing allows to discriminate the levels of utility, while regulation treats all the subjects in the same way, not discriminating in relation to the marginal benefits. Although there are some redistribution effects that must be considered. In fact, while regulation does not require monetary costs, even if it may be a cause of loss of welfare, application of taxes involves an income for the State and an expense for the user.

For example, a regulation which limits the access to an urban area, in relation to pollution levels or congestion when the acceptable maximum limits are



exceeded, requires only a decree of the Mayor in order to block the circulation to motorists and adequate law enforcement to be effective.

The introduction of a tax, or toll, demands the determination of an efficient level, the institution of an organizational structure that takes care of the tax, toll or fare collection, and control evasion. For the characteristics of the necessary organization the application is therefore not immediate.

A consideration on property rights must be added. The use of the roads, and therefore of on road parking, affects a resource of the community, therefore it must be considered as the use of a public propriety.

One of the characteristic that distinguishes public assets from private assets is the rivalry in the consumption. Collective services are characterized from the fact that the use by an individual is compatible with the use of the same one by more individuals. In economic terms, it can be asserted that the collective character of a public good consists in the fact that adding one or more consumers does not involve an increase of cost in the production or distribution of the same service. On the other hand, if the use of a public asset by one individual limits its use by others, as in the case of road space in parking, a compensation to the community by the individual who benefits of the public asset is required.

3 Parking policies

To reduce these external costs, which weigh on the entire population, some control policies can be adopted, of monetary nature and non-monetary nature.

Among these there is urban road pricing, requiring the payment of a toll in order to enter in the zones subject to the greatest traffic pressure (city centre, central business district CBD) and/or in order to engage the street lanes. The amount to be paid is in relation the externality level produced from motorists.

Paying for parking, a well-established practice in most countries, applies the principle of road pricing making parking schemes an effective tool of traffic management.

In the zones where supply of parking space is inferior to demand, opportune regulation must be adopted in order to discourage the use of private vehicles, especially of those which engage in trips which require long stays in the interested zone, taking up valuable space.

Measures in order to contain the use of private vehicles must be accompanied by an integrated policy of public transport and qualification of pedestrian facilities. An integrated parking policy cannot be based exclusively on reorganization of on road parking, but a strategic planning for car parks is required, finding areas and finance for off-road parking space.

Policies for parking management are fundamentally of two types:

- Tariff policies
- Regulation policies

Either of these is useless in absence of an adequate enforcement and repression of illegal parking.

Tariff policies basically require the adoption of payment for parking (e.g. pay and display), and the adoption of rates which can be differentiated, between



parking at destination (located in the city centre or CBD) and the exchange car parks, located in the suburban zones. The choice on the adopted tariff for off and on road parking is influenced by financial parameters and the adopted traffic control policies.

Regulation policies can require generalized restrictions on parking, in determined areas and in determined time slots (e.g. peak hour), this way discouraging the use of private vehicles (e.g. for systematic trips). Limits can be applied on the length of parking time, as in certain cases the cost of parking is not sufficient as deterrent.

4 Pedestrian routes

Beyond vehicular traffic and consequently the necessary spaces for parking, there are other causes which contribute to make pedestrian mobility in the city an uncertain variable. The application of traffic related appliances, such as traffic lights, indication and signal poles, road illumination, barriers and similar, can prove to be a further deterrent to pedestrians. To encourage drivers to use parking outside the congested area, the arrangement of adequate pedestrian routes was considered fundamental. An analysis of the territory allowed the definition of the routes and a project was developed to rearrange all potential obstacles. It must be said that in many cases this aim was reached with relatively low financial expense. Furthermore, part of the road space recovered from spaces freed from on road parking was used to enlarge the sidewalks. The scheme required also infrastructural variations, as at level crossings, ramps and other actions with particular attention to the weaker categories (children, elderly, physically impaired).

A particular role in the design of the pedestrian routes is held by raised pedestrian crossings. These can be simply considered as a vertical variation of the geometry of the track on the longitudinal profile of the road axis.

The raised pedestrian crossings are used especially in cases in which it is not possible to eliminate the components from traffic flows of through traffic.

The criterion adopted on the choice of location of the pedestrian crossings is generally that one of the continuity of the routes, therefore the preferred location is in correspondence of intersections. The location of pedestrian crossings can be decided also based on the intensity and the nature of the service on one or the other side of the road, and act as generators of pedestrian mobility: stores, schools, recreational areas, public offices.

In the case of the adoption of raised pedestrian crossings, it must be said that to the function of pedestrian crossing is associated that one of speed moderator.

Returning to the characteristics of the raised pedestrian crossings it is the case to speak more exactly of rising of the road track, and the new road code, requires that the width of the pedestrian crossings on local or city roads must be not inferior to 2.50 m.

5 Application in the study area

The city of Villa S. Giovanni is a small city include in a vaster metropolitan area, the high population rate and density of traffic attractors, combined with the parking by commuters which travel daily to Sicily, causes devastating impacts on the urban mobility, which already suffers for the congestion due to local traffic.

Unregulated parking has led to unsustainable levels of congestion, but the size of the city and the distribution of activities, developments mixing residential and commercial units, a high construction rate in the centre against a low density in the suburban area, and the business district operating an attraction influence on an area of significant dimensions, makes the abolition of on road parking a not viable option.

In this context a parking scheme was adopted. The study was developed within the guidelines of the Urban Transport Plan adopted by the city, to design detailed actions to reduce congestion and pollution, and increase urban quality. Among the proposed actions, one of the priorities set by the Plan was the adoption of parking policies and pedestrian routes.

6 Analysis on existing parking

In the case in study an analysis was led to determine the characteristics of parking, the parameters, the availability and nature of spaces on road and off road, for the different city zones.

An aggregated analysis by great areas (centre, suburbs) showed that parking supply appeared more than sufficient; but a disaggregated analysis by zones shows a supply deficit in the centre. The lack of parking areas resulted in illegal parking, and parking spilling in adjacent areas, with consequent loss of lanes and reduction of road capacity on some strategic arteries, and obstacle to the circulation of vehicles and pedestrians.

Table 1: On road parking supply in urban area.

<i>zone</i>	<i>surface (Ha)</i>	<i>parking spaces</i>	<i>spaces /Ha</i>
<i>A) Tot external crown</i>	<i>321.77</i>	<i>2831</i>	<i>8.80</i>
<i>B) Tot. city centre</i>	<i>47.50</i>	<i>1314</i>	<i>27.66</i>
<i>Total A+ B</i>	<i>369.27</i>	<i>4145</i>	<i>11.22</i>

In Table 1 the total supply and density of on road parking by zones, central area and external crown, is shown.

Before the adoption of the parking scheme all the available parking was charge free. The total supply of parking space in the perimeter of the centre was of 1314 spaces, on a surface of 47.50 hectares, and a total of 4145 spaces on

369.27 hectares of the urban area. The same urban area counted a total of 12,395 residents, 4032 families, with a rate of car ownership of 0.56 on the total of the population, and 0.89 on the population with a driving licence. The employees in the activities of the area are 3589. A survey was led prior to the analysis of the statistical data, in order to assess the parking demand, recording the occupation ratio and length of time of parking.

In particular surveys were led on a week for 24 hours in the month of June on main roads and car parks of the study area, counting legal and eventual illegal parking. A campaign of interviews to users, to assess the nature of the trip, the length of average parking and related questions was also run.

In table 2 a comparison is given between parking spaces supplied and demand in the zones.

Table 2: Demand/supply ratio measured in the urban zones.

<i>zone no.</i>	<i>parking spaces</i>	<i>vehicle demand</i>	<i>spaces /Ha</i>	<i>presence /Ha</i>	<i>Supply Surplus</i>
<i>A) Tot ext. crown</i>	<i>2831</i>	<i>1020</i>	<i>8.80</i>	<i>3.17</i>	<i>1811</i>
<i>B) Tot. city centre</i>	<i>1314</i>	<i>1252</i>	<i>27.66</i>	<i>26.36</i>	<i>62</i>
<i>Total A+ B</i>	<i>4145</i>	<i>2272</i>	<i>36.46</i>	<i>6.15</i>	<i>1873</i>

The estimated parking demand, based on the O/D and survey data, is referred to a hour of high demand, considering 11.00 a.m., in mid morning. In the external crown area demand is contained, parking supply is greater than vehicle presences therefore deficit situations were not recorded; however the more critical situations were found in the central area.

The parking demand in all the monitored area shows a growing trend during morning hours reaching the maximum value in the interval 10.00-12.00 a.m. to then fall abruptly at 2.00 p.m.; in the afternoon hours after 3.00 p.m. demand started to increase again with a peak between 5.00 – 6.00 p.m., in particular in the roads next to the railway station, to decrease subsequently up to the minimum values during the night (residential parking).

In the survey the number of parking spaces was counted. A further parameter to evaluate the demand/supply ratio adopted is vehicle spaces*time, assuming as time unit the hour, and for the particular area 12 hours in the day, therefore with 1341 parking spaces we considered 16092 spaces*hour.

7 Application of the proposed scheme

In the zone where the main city centre falls, the need of higher standards for parking and pedestrian facilities required a reduction of on road parking spaces, and the parking demand to be compensated involving a modulation of the time – density parking supply.

The pursued aims (discouragement of long stay from the higher demand zones and greater supply for short stay stops) are the base for the policies proposed, with regulation and dissuasion of parking, using a mix of tariff and time restrictions in the entire city centre which includes a Control Traffic Zone (ZTL) introduced by the Urban Traffic Plan.

Subsequently to the study, on the base of the results and the indications contained in the directives of the Transport Plan, the infrastructural and regulatory actions were proposed.

The plan requesting the facilitation of pedestrian mobility and the elimination of the parking on some arteries, contain the indications for the construction of off road parking in the areas adjacent to the centre, and the a scheme of payment parking extended to the whole of the Limited Traffic Zone, and a time restrng policy on the adjacent zones, to discourage spilling of parking to the confining residential areas.

In the Limited Traffic Zone and in the surrounding crown 800 spaces of on road parking were dedicated to the payment parking scheme.

On the base of the study on the actual demand payment is limited to two time periods, from 7.30 to 12.30 a.m., and 16.30 to 19.30 p.m., excluding the payment at noon and the first hours of the afternoon, and night hours. This is due to the drop of request which corresponds to the closing time of offices and commercial activities, and consequent fall of parking demand. The reduction of the pay and display time allows a reduction on the running costs of the parking scheme, and proved more popular with residents, not affecting with parking costs a period which involves people returning home for lunch. Sunday parking is free.

A concession to residents was introduced, allowing a free parking pass per family for the first car, and the opportunity to buy a yearly pass at a reduced rate (150 euro) for the second car. The use of all available parking spaces is free to vehicles in service for official use, (i.e. public forces, doctors on visit), and vehicles of people with limited physical abilities, which can also use the reserved spaces, which were introduced in a minimum of 1 every 50 spaces, and close to all main building and offices.

The tariff was fixed, by indication of the City Administration, in 0.50 euro per hour or fraction. The limited extent of the area discouraged the idea of a tariff differentiation for zones.

For the management of on road payment the system of Parking Vouchers, was adopted, being the system economic, simple and offering a prepaid service.

The use of the Parcometers would present some advantages for user and administrators, but were not adopted for the set-up cost of system weighing on the operating costs.

The good functionality of the parking scheme depends directly on the presence and vigilance of operators designated to enforcement. In order not to distract the municipal police from other services, a team of traffic wardens was enrolled.

The first phase of the scheme has seen the application of the on road parking scheme, the pedestrian routes are in the phase of construction, while the procedures for the definition of the off road car parks are in course.



After the activation of the parking scheme a survey was led, to measure the parking demand/supply with the applied scheme. During the hours in which the pricing scheme is in function, the average parking time has fallen significantly compared to the values measured before the regulation, with an average value on the total of 2.08 hours. This is more evident if referred to the single roads, where there has been a reduction up to half the parking time, which implied a higher number of vehicles meeting demand satisfaction.

The scheme reduced on road parking spaces of 140 spaces within the central zone, counting as spaces also those which previously had been used even if not respecting size standards. The reduction of supply of parking spaces, did not reduce the satisfaction of demand, by the combination with the reduction of average occupation time. It was estimated that there has been an increase in satisfied demand of up to 34%.

However the choice assumed from the City's Administration must hold in account the revenues in reference to the running costs for the management of the Scheme, as the costs for the running of the scheme should not weigh on other sectors of the urban government. On the other hand if and where there are "revenues", these have to be reinvested in mobility to sustain the scheme, as the functionality depends on it being part of an overall integrated transport policy.

From interviews, it was observed that as a collateral effect there was a reduction of time on the system researching for parking space, which translates in less congestion and less pollution. Even if illegal parking has not been completely eradicated, it is reduced to a more limited set of points of the network and time of day, but on the overall there has been an increase of accessibility. Completing the pedestrian routes and with the use of further 350 off road parking spaces further results are expected.

8 Conclusions

A sustainable approach to the government on urban mobility is based on general aims, which have to be followed by defined strategies. To improve the transport and mobility systems, limiting externalities, a set of policies and actions have to be defined and applied.

The process of design and application of an Urban Transport Plan developed for the town of Villa S. Giovanni, presented in its aims and strategies, in the analysis of the system before and after shows that optimization of traffic control is directly linked to the adoption and enforcement of specific parking policies.

The design and adoption of the plan was preceded by the analysis of parking demand and supply, road occupation, requiring a specific survey.

Unregulated parking has led to unsustainable levels of congestion, and the analysis of the system showed.

During the hours in which the pricing scheme is in function, the average parking time has fallen significantly from an average value on the total of 3.13 to 2.08 hours.



The reduction of supply of parking spaces, did not affect the satisfaction of demand, by the combination with the reduction of average occupation time. It was estimated that there has been an increase in satisfied demand of up to 34%.

The adoption of a proposed Public transport system would allow to take in consideration a significant reduction of on road parking space, but until there are the conditions of an efficient LPT system any proposal of road parking reduction would require great cost in terms of law enforcement, with a small chances of success, therefore low levels of effectiveness.

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