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Envisioning Parking Strategies in the Framework of Sustainable Urban Transport

Politiche per la sosta all'interno di visioni strategiche per la mobilità sostenibile

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Le politiche per la regolamentazione della sosta sono uno degli strumenti a disposizione del planner per la governance della mobilità urbana.
La corretta ubicazione e dimensionamento delle aree di sosta concorre infatti a determinare un utilizzo efficiente del sistema della mobilità (o può ostacolarlo, se tali infrastrutture non sono opportunamente inserite nel sistema dei trasporti). In questo framework, la pianificazione delle aree di sosta assume nuove priorità associate all'integrazione del sistema dei trasporti, ed al governo del territorio finalizzato al contenimento dell'impatto ambientale.
Nel quadro delle politiche per una mobilità sostenibile, un ruolo strategico è associato quindi alla pianificazione e gestione delle aree di parcheggio, la cui realizzazione deve rispondere ad un'oculata allocazione delle risorse disponibili, ed alla limitata disponibilità di suoli nelle aree urbanizzate.
In questo contributo, lo sviluppo di politiche per la gestione della sosta è discusso in relazione alla realizzazione di alcuni recenti interventi nella città di Bari. L'attenzione è spostata dagli effetti di breve/medio termine, di interesse per la pianificazione tattica e l'ingegneria del traffico, agli effetti di lungo corso nella pianificazione strategica.
La disponibilità di strumenti per la modellazione integrata dei trasporti e del territorio espande le possibilità di analisi degli impatti di tali politiche, in termini di effetti nella formazione di comportamenti di mobilità e dell'utilizzo dei veicoli privati, e dell'evoluzione futura del sistema urbano.

Introduction

Parking is indeed an important element of the transportation system of any city. Its organization represents an important task for traffic engineers: if well planned and managed, parking facilities may considerably increase the accessibility of urban settlements, and they contribute to reduce congestion in urban areas. However, the definition of parking strategies entails a not trivial task: parking strategies and regulations deeply affect the use of cars, and of transportation more generally. When correctly located, parking lots may efficiently support the use of the road network, and reduce the number of vehicles miles travelled by private vehicles. Besides, parking strategies may be often useful to promote public transportation, when designed in coordination with the development of mass transit infrastructures.
At the beginning of the 21st century, parking facilities cannot be designed separately from the remaining elements of the transportation system for several important reasons. The development of parking facilities in fact entails important issues related to their interactions with the other elements of the transportation network. Besides, their construction requires huge investments, both in terms of financial instruments and in terms of consumption of natural capital (developable land), which is often a scarce resource in central areas. For these reasons, in a time of increasing environmental concerns, it becomes cautiously important to link the design of parking facilities to the broader processes of development of sustainable transportation solutions for our cities and metropolitan areas.
Generally, parking facilities are land intensive infrastructures that stimulate in the medium run more demand for trips by private vehicles. Thus, an increase in parking capacity usually leads to additional vehicles traveling on the road network, and a stronger *car dependence* of transportation. This

The location of parking facilities is a major issue of transportation planning.

phenomenon makes the increase of parking capacity desirable only for a limited amount until reaching an optimal level. After this limit, it makes the environmental quality of transportation gradually worsen, with higher demand for additional road capacity and even more parking capacity, which not always may be satisfied due to land availability constraints. Moreover, additional concerns are related to the adoption of land use patterns associated with huge parking facilities. They contribute to shape the new developments, in particular in suburban areas, with the formation of a more car-dependent mobility and a reduction in the accessibility by walk/public transportation. The process determines the formation of large energy intensive (and energy wasting) systems, with associated lower quality of life and environmental decay.

Parking regulations and strategies deeply affect the use of the transportation system, through the transportation costs associated with the use of parking facilities and the time required to access them. The financial instruments for the regulation of parking are a powerful tool for local administrations to collect additional revenues, and raise flows of capital that cover the management costs of parking facilities and may finance other investments in transportation-related projects. Moreover, pricing policies have relevant effects on the mode share and on the use of the transportation system. Most users are usually sensitive to parking costs, especially when other valuable transportation options are also available. In the perspective of the global governance of the urban mobility, the policies for the regulation of parking may indeed play a considerable role. As elements of a comprehensive strategy to address more sustainable mobility, they may significantly contribute to meet the goals of a balanced mode share, and of reduced environmental externalities of transportation.

In this paper, the issue of the coordination of parking strategies within the process of development of the transportation system is discussed with regard to their potential to support more environmental-friendly travel solutions. The issue is discussed with regard to the implementation of several projects in this field in the city of Bari (Italy). The paper discusses the way these projects are linked to any broader strategies for the urban mobility, and if they may be merged into policy packages to pursue more sustainable transportation. The way in which the effects of parking strategies can be modeled into a long-term strategic model of future development of the city (a land use transportation interaction model) is then presented in the following section. The final section draws some conclusions on the role of parking as part of long-term strategies for transportation in urban and metropolitan areas, and on the other issues addressed in the paper.

Parking facilities in the framework of planning for sustainable cities

Parking facilities are an important element of the transportation system of a city. Nevertheless, their design and organization is often disregarded, and most attention focuses on the construction of other elements of the transportation system and of the road network. Somehow, the existence of sufficient space dedicated to the parking of motor vehicles is given as granted in the design of most cities and neighborhoods. As a result, the importance of the role of parking space, either along public roads or on private areas, is usually underestimated (with a few limited exceptions), and not investigated as it should be required. According to the definition of the dictionary, a parking lot is simply "an area used for the parking of motor vehicles"[1]. The definition itself is vague, and many different ways for organizing parking facilities actually exist. Therefore, the choice of the best solution for each context should be carefully made in conjunction with the overall objectives leading to the definition of the parking policies in a municipality and/or local administration. Many times, however, and especially in those cities that do not host strong planning authorities, parking facilities are located in an arbitrary way, through the addition of extra capacity to the existing on-street parking where possible, and gradually occupying the remaining areas which have not been developed for other purposes yet. This inevitably leads to a lack in the efficiency of the solutions adopted, and in their ability to solve transportation needs.

Nowadays, there is certainly the need to address the development of parking facilities in a wider perspective, and in the framework of more inclusive planning strategies for urban mobility. This need is even more urgent due to

Structured parking overcomes the scarcity of developable land in central areas.

the necessity of quickly making transportation system more sustainable, and of reducing the externalities of transportation. The environmental impact of transportation is mainly associated with the use (and often *misuse*) of cars and private vehicles. As already mentioned, the design of parking facilities greatly affects the use of cars in urban and suburban areas. Hence, the approach used in their development may actively contribute to rebalance the use of transportation in more congested areas, if part of an overall strategy for sustainable mobility.

Since the first definition of *sustainable development* by the Brundtland Commission (World Commission on the Environment and Development 1987), many alerts have been launched on the need for urgent measures to reduce the environmental impact of human activities. A huge debate has followed (Daly 1990), but small efforts have been made so far to design operational and logically consistent plans to "green" society, and to reduce the impact of mankind on the ecosystem. This highly regards transportation projects.

Transportation is nowadays responsible for about one third of the total energy consumption (U.S. Department of Energy 2006) and emissions of greenhouse gases in the atmosphere, and its share of energy consumption and pollutant emissions is increasing (U.S. Department of Transportation 2006). Moreover, at least for what it concerns most developed countries, transportation of passengers is disproportionately directed toward the use of automobiles (Chapman 2007), with an almost total dependence of private mobility on the combustion of fossil fuels (oil and/or natural gas). The dominant use of cars is the cause of the depletion of natural resources and of soil degradation and increasing urbanization, due to the construction of new roads and highways, and the increase in the capacity of other transportation facilities (Crawford 2000).

From this perspective, the redefinition of policies for transportation in urban and metropolitan areas assumes immediate priority among the objectives for a reduction of the environmental impact of transportation. This relates to the definition of global strategies to green our cities, which must include interventions on both the land use and the transportation system. Their objectives must match an equilibrated and smart growth of new developments with the adoption of mass transit solutions, and the construction of roads and other transportation facilities in the already built areas. Although several studies have dealt with the relationships between land use and transportation systems, to date still there is little evidence, however, concerning what is the ideal settlement structure from the point of view of sustainable transportation (Greene and Wegener 1997).

The idea of linking the development of land use with an equilibrated development of the transportation system that is not dominated by the use of cars has inspired the movements for the *smart growth* (Handy 2005) and the *New Urbanism* (CNU 1998).

The common background is the awareness that urban areas featuring mixed land use, and higher density of settlements, if properly designed in coordination with transportation usually leads to higher efficiency in transportation and reduce urban sprawl and environmental externalities (Newman and Kenworthy 1999).

The concept is developed in the definition of the *transit oriented development* (TOD) of neighborhoods and new areas in which all efforts are made to promote a dominant use of transit facilities (Cervero 1998; Dunphy et al. 2005). In the short term, TOD solutions maximize the benefits of the investments in transportation systems, supporting the increase in density, mixed land use and urban quality along

Some municipalities have developed large car-free pedestrian areas that sometimes are even "bike-free".

the transportation corridors. In the long run, they cooperate in transferring travelers to public transportation, and in limiting the urban sprawl.

In these processes, the overall strategies for establishing less-car dependent settlements involve interventions to promote both public transportation and the alternative environmental-friendly travel options named under the non-motorized "soft mobility". Besides, they require the adoption of dedicated design for road and parking infrastructures. Important projects have already reached quite successful results in this direction in Europe, North American and Asia. An additional contribution derives from the adoption of *travel demand management* (TDM) solutions, which reduce demand for traveling by private vehicles (especially if "driving alone", i.e. the most energy intensive travel option), and of traffic calming measures, which actively contribute to reshape the road network and the overall transportation infrastructures.

With these objectives, the major interventions on the transportation system should address the coordination of public transportation solutions, including subways, local and urban railways, light rail systems/tramways and bus services, with the development of the road network. The design of parking facilities should match these overall goals, in order to adequately support the use of transportation and improve the efficiency of the system, in which public transportation attracts a significant amount of travel demand (Black 1981; Meyer and Miller 2001). The development of transfer nodes for multimodal transportation allows the physical integration of networks, expanding the accessibility of the system.

In such a multimodal system, an important role is associated with the supply of the optimal amount of parking space. The right location and design of parking lots allows the proper development of the road network, and supports proper access for private vehicles and door-to-door service. However, overcapacity in the supply of parking facilities eventually causes heavy effects on the use of private vehicles, conferring too high attractiveness to the use of private vehicles, and increasing the modal share for cars in spite of the use of alternative means of transportation, and in particular of mass transit. Besides, an incorrect design of parking facilities concurs to an excessive consumption of the available land (either natural or subtracted from alternative uses), and weakens the geographical cohesion of the urban structure. Urban patterns with broad avenues and large parking facilities facilitate the use of cars, and reduce the accessibility for pedestrians and bicycles (as a result of the larger distances among blocks and facilities). They reduce the density of the settlements depowering the implementation of transit solutions. Moreover, overcapacity is generally quickly absorbed by the market, as an effect of the induced demand attracted by the availability of additional parking space, and as a consequence of the reduced accessibility with the other means of transportation.

Parking facilities include varied solutions, ranging from the on street parking (common in most residential areas and suburban neighborhoods with low density) to conventional or underground multi-store parking facilities. These facilities can facilitate the access of users to terrestrial infrastructures (railway stations and bus terminals) if properly planned in the framework of multimodal transportation. The objective of the promotion of public transportation solutions has successfully lead to park and ride (P&R) facilities, in which the traditional "walk-in" access of transit is complemented (if not substituted in suburban areas), by a "drive-to" access, increasing the area of influence of transit terminals and stops.

On-street parking, the easiest and cheapest way to provide parking space, is indeed land intensive. It subtracts important surface area from other uses, e.g. reducing road capacity, and is not well suited for providing sufficient parking space in high-density areas. Surface parking may be a good solution for suburban areas, where land is cheap and available

in larger amount, and it allows creating surface parking lots close to the locations that originate the travel demand. More expensive structured parking is the solution often chosen in central areas of the cities, where land is more expensive and scarce (Dunphy et al. 2003). Structured parking facilities, either underground or in multi-store dedicated buildings, are significantly more expensive than surface parking, although their cost is often more than compensated by the reduced amount of land required, and by the potential revenues deriving from the exploitation of the parking facilities. These parking solutions are usually located in the central areas of larger cities, in proximity of the Central Business District (CBD), or of important points of attraction as fairs, important transportation nodes (e.g. railway stations and airports), amusement parks, etc. These solutions require huge financial investments, which are seldom justified by local demand in lower density areas, where undeveloped land is available.

The use of financial tools to regulate the access to parking allows influencing the use of cars in urban areas, as part of the overall strategy to organize the transportation system. Time and costs (which can be generally collapsed into a comprehensive term, if we refer to the generalized cost of transportation) deeply affect users' behavior in the short term, and contribute to the formation of long term preferences of travelers. Therefore, these effects have to be taken into account in the evaluation of the impact of policies in the urban area. In the remaining of the paper, the role of parking facilities as part of broader transportation strategies is discussed with reference to the development of some projects in the city of Bari (Italy). In the case study, the role of parking is analyzed in relation to the long-term effects associated with the development of strategic planning of the city. The availability of planning instruments that can assess the effects of such policies is presented as crucial for the evaluation of the response of users to parking policies, as well as of great usefulness for planners and local administrations for estimating the long-term effects involved in the development of transportation strategies.

Parking strategies in the city of Bari

The discussion on the implementation of parking strategies will now focus on some recent projects that were designed and later developed in the city of Bari (Italy). The interventions were part of various strategies pursued by the local administrations over a time span of almost 15 years, in order to reorganize transportation in the central area of the city. Different strategies were implemented in this region, according to different visions of the future development of the city. Such differences are revealed in the way parking facilities have been planned and designed. Some elements of the organization of transportation and parking, which were mainly designed as traffic calming measures with a short-term horizon, are common to all packages of policies designed in this time span. However, a significant change in the policies to enforce was recorded because of a change in the actions of the local government, and as a consequence of a change of the political coalition leading the city council of Bari in 2004. The possibility of merging some of the different projects into a whole strategy that envisions a more integrated development of the transportation system is presented at the end of this section, when the topic of the definition of long-term strategies for the metropolitan area of Bari is discussed.

The use of structured parking at the end of 1990s

According to the 2001 census data, about 320,000 inhabitants live inside the administrative boundaries of the city of Bari. The total population of the metropolitan area of Bari, however, sum up to almost one million residents, with a total population of the province that exceeds 1.5 millions. Important changes are registered in the demographics of the area: while the population of the city of Bari has been mainly stable, if not even decreasing over the last 40 years, the smaller settlements surrounding the city have experienced a sharp increase in their population. Nowadays many of the residents of the smaller towns in the metropolitan area commute to the central area of the city, with additional relevant traffic flows directed to other destinations as the industrial areas surrounding Bari, and several commercial areas in the immediate proximities. The transportation system serving the area has not grown with the same pace though, and this has determined a significant increase of congestion on the main roads and freeways of the region. Various local bus companies operate regular services among the centers of the metropolitan area, while a publicly owned company runs the urban bus services in the city of Bari. Railways services connect many centers, too, even if they do not serve the whole population of the region, and the services scheduled on many secondary lines have lower quality of service.

In order to reduce congestion and provide enough parking space to commuters, at the end of the 1990s the city hall of Bari promoted a huge plan of investments that involved the construction of several structured parking facilities in the city. The plan was supported by the requests of the population, asking for better parking in the central area of the city, and supported by the lobbies of storeowners and retailers of the area, worried about the declining revenues of their activities associated with the reduced access and the difficulties of parking in downtown Bari.

The strategy behind the interventions was clear: the planning offices of the city hall aimed at reducing surface traffic congestion through the construction of a relevant

number of parking spots located in the center of the city. At the same time, part of the on-street parking on the avenues to access the area was eliminated, increasing the accessibility by car to the central area. The adoption of road pricing would have limited the access to a restricted area (almost one half of historic downtown), further reducing the traffic flows in this area, and making traveling to downtown more expensive (for the combined effects of the congestion charge and parking tolls). It would have drastically reduced the volumes of car accessing the central area of downtown, but caused additional congestion on the boundaries of the restricted area.

The plan relied on the use of car as the central element of the transportation system, with only a calming effect on traffic due to the increased capacity of the road network and of the parking system, and the road pricing system. Long-term interventions on transportation were poor and missing, thus undermining its stability in a long-term perspective. In the authorities' plans, the adoption of parking fees for on-street parking in downtown would have reduced the average duration of stands in downtown, thus further increasing the capacity for short-term parking. This should have stimulated shopping activities and the whole economy in the area.

Indeed, the plan lacked of a comprehensive vision to the problem, and of sufficient support to the development of public transportation. In those years, mass transit solutions were only encouraged with the enhancement of the railway services on the north-south corridor, and the establishment of metropolitan services on the terminal lines run by the national railway company. A new metropolitan railway line was designed for connecting the neighborhood of San Paolo. However, this would have entered into service only several years later.

Bus services remained mainly unmodified. Eventually, a few dedicated bus lanes were converted into regular car lanes in the effort to speed up traffic flows. Alternative non-motorized travel solutions, mainly bike and pedestrians, were not significantly supported, if not only marginally by the reduction of the on-street traffic volumes in downtown. No specific projects for the development of a bike lane network or for the increase in the size of pedestrian areas were approved. Only exception, the medieval center of the city was completely closed to private traffic – however, this represented more a project of urban requalification rather than an intervention on transportation, due to the small amount of traffic volume in the area.

The transportation and parking strategy designed during these years, indeed, failed to meet their goals. In part due to some delays in the implementation of the system, and to the opposition of important groups of stakeholders among the population, the road pricing system never started operation. Having been originally designed on a too small area, the system was installed with all the construction costs associated with its implementation. It therefore constituted a large waste of funds, in a time of financial constraints for public investments that further reduced the opportunities associated with alternative projects in the region.

Several technical issues and difficulties in the construction of the underground parking facilities delayed their development. This was due to some design faults, in particular in relation with the detection of underground water. Of the three main underground facilities included in the plan, only one was completed a few years after the adoption of the parking strategy. The construction of a second one was significantly delayed with its delivery estimated for the end of 2009. This means several years after the original design took place, and in particular long time after the overall transportation strategies of Bari had been heavily modified.

Behind the failure of these plans, an unpopular truth stands. Largely built in a time in which car ownership was quite limited, as in many other European cities the road network of Bari was not able to support heavy traffic volumes. It was planned for small amounts of public transportation vehicles and pedestrians flows. No interventions have later significantly modified this equilibrium, even the projects that reduced sidewalk width in order to increase road capacities few decades ago. The ambition of the transportation and parking strategy of the end of the 1990s did not elude from this rule. Bari was not supposed to become a totally car dependent city.

Traffic calming measures at the beginning of the XXI century

A modification in the objectives of transportation planning started few years later. The change became more evident after the political elections of 2004, as a result of the change in the political majority leading the city hall. This significantly modified the political agenda at the local level, and brought new priorities in transportation strategies.

The new course of local planning agencies developed a different strategy to address transportation issues in these years. This mainly related to the combination of private travel solutions with public transportation. The aim was pursued through the introduction of three new bus lines on radial routes to/from downtown, which today serve "park and ride" facilities for inter-modal trips. Three large parking facilities were integrated in the network. A new surface parking lot was inaugurated near the city park Due Giugno in the Southwest part of the city. Besides, the plan included the use of two already existing parking lots on the North and South side of the city. The new lines were operated with modern buses (above the average level of comfort offered by the local transit company), and on a regular schedule with high frequency on all routes. A competitive

fare allowed combined access to parking facilities and the bus service, with a resulting transportation cost below the average of the other solutions to access downtown.
At the same time, the local government promoted the integration of alternative travel option solutions. They promoted the construction of new bike lanes, which constituted the first branches of a future network, and that connected the neighborhood of Carrassi, a semi-central high-density neighborhood, with downtown. Moreover, an ambitious plan of bike sharing (inspired by the similar projects in cities like Vienna and Paris) started with a limited number of bikes available for local commuting trips at several locations.
Some of the solutions designed in the previous period were also confirmed. This is the case of the parking fee policies, which have been extended to additional areas and now cover the entire city center. The fees make long term parking more expensive to discourage the use of car for regular commuters. Additional efforts were made to reduce congestion and deal with the scarcity of parking space in the central area of the city, with the increase of parking capacity. This was achieved with the completion of one of the main underground structured parking facilities designed in the previous years (which was close to its delivery at the time this paper was written). Besides, it included the design of another big surface parking lot not far from the main railway station of the city. This additional parking lot was quickly opened to service in order to face the increased demand in the central area of the city. The parking lot was built as a temporary facility on the land made available by the dismissal of a large military area (Rossani), located in a very central location.
After the Army had dismissed the area, many redevelopment ideas were proposed for its reuse. Proposals included a bus terminal, which would have increased the strategic role of the adjacent train station as the main multimodal terminal of the city. The area was supposed to convert to a city park according to another proposal. This proposal received high interest also due to the location of the Army base in a neighborhood with very limited amount of green areas.
Therefore, the construction of the parking lot on this portion of land determined a change in the other plans for the area, and a (supposedly temporary) disruption to its redevelopment. This was only one of the issues arising in the transportation policies of recent years. An endemic bug again appeared: the focus on midterm oriented actions in

New design for Cesare Battisti Square in downtown Bari, after the construction of a huge underground structured parking facility.

Redevelopment project of the ex-military area “Rossani” in the city of Bari.

planning, with a dramatic lack of long term objectives for the future development of the city. This was evident in transportation planning during the years 2004-2009: the case of the ex-Army base was only an example of an area available for green areas and city parks (or, at least, for the construction of an important bus terminal) that was quickly converted into a surface parking area. The same lack of coherent choices was found in the definition of mass transit priorities, and in particular for one of the park and ride lines. The parking lot at the end of this line is located in the immediate proximity of a city park (on a portion of land that should have been designated to an expansion of the city park), in the semi-central neighborhood of Carrassi. This constitutes a non-sense from the point of view of the efficiency of the system, since it attracts additional private vehicles in a semi-central area, and originates more congestion in this neighborhood.

Again, the long-term impact of the new line has not been carefully explored. Moreover, a future extension of the line with the relocation of the park and ride facility far from the central areas has not been designed. In the same way the substitution of this congested bus line with a high capacity solution –a light rail system (commonly defined tramway in European countries) to connect the neighborhoods of Carrassi and Carbonara with downtown– has not been planned yet.

Although the planning offices have addressed the issue of the coordination with alternative mobility networks (in particular, the construction of bike lanes), these interventions to date remain very limited. In particular, the safety and the quality of the design of these networks and of their intersections is still not enough studied. Besides, technological and operational difficulties severely limited the success of the local bike sharing program. The lack of an operational credit-card based system, as implemented in other European cities, has so far limited this not very successful experiment, losing a source of revenues, and limiting the access to the service to a restricted group of registered users.

All these elements of criticality reduced the potential quality of the solutions introduced. This came even more unexpected if considered the contemporary establishment of the metropolitan planning organization (MPO), which took the duty of envisioning the future development of the area, and inspiring the planning process with strategic visions inspired by the principles of sustainability and of the reduced environmental impacts of human activities.

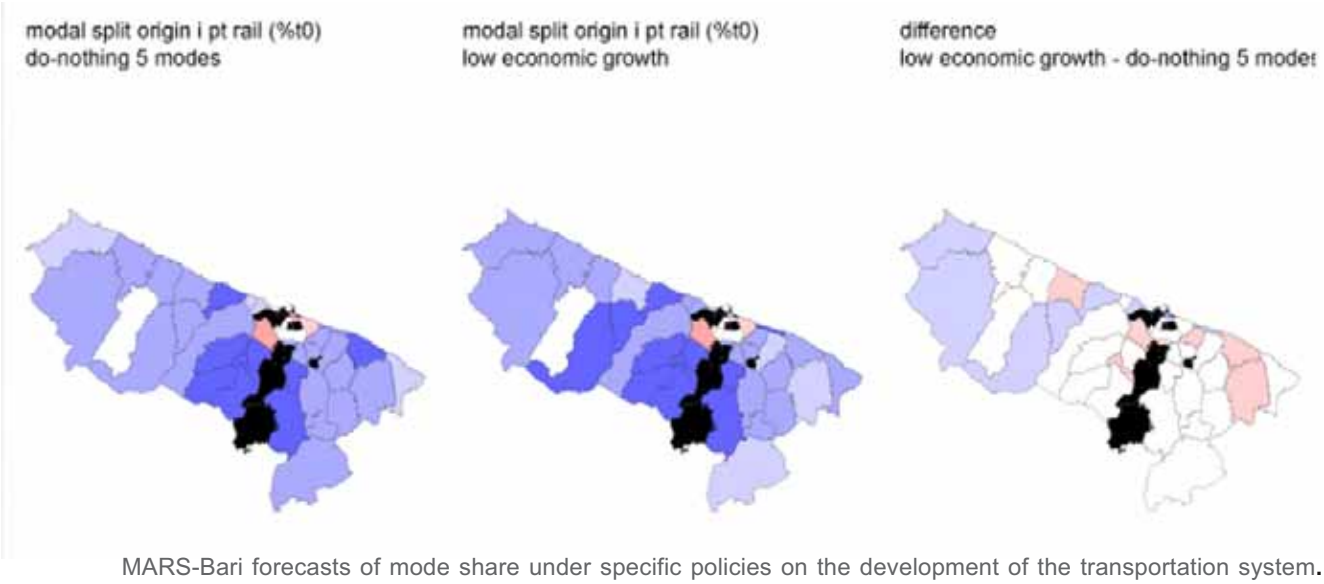
The parking plan was developed as part of a global vision for transportation. This included parking fees for on-street parking in the central business district, the reduction or even elimination of on-street parking on the main branches of the road network, in order to reduce traffic congestion, and increase capacity and commercial speed of vehicles to/from downtown.

A sophisticated road pricing system regulating the access to a limited central area of the city was designed. The access to a restricted area of downtown was regulated by the payment of a toll, similar to the congestion charge projects developed in London and in many Italian cities in previous years.

This would have generated additional revenues to finance transportation projects in the city, and reduce the amount of cars accessing the area.
Apart from the construction of some structured parking facilities in other areas (the most significant one serves the largest hospital of the city), the parking strategy included the development of three main underground parking located under the main squares of the city. Two of these parking facilities were to be developed in the downtown, while another one should have been located under Giulio Cesare Square, in a semi-central residential area, which has faced increasing congestion in the last few decades.
The non-linearity of planning actions is somehow also mirrored by the apparent confusion in the definition of the projects for the improvement of the road network capacity. Behind the approval of several road construction projects, the overlap between primary (more important) and secondary (more local) branches of the road network is often evident, as witnessed by some recent projects that duplicate not very useful road links, without reducing the real bottlenecks on the network.
Summarizing, the overall planning process of these years has resulted in a contradictory process: from one side it worked on taking cars out of the central areas, and reducing the dependence on private vehicles. On the other hand, it did not provide long-term solutions for mobility, and in particular for commuters who do not commute by car, and are not served by the new park and ride lines. Besides, the construction of the new surface parking facilities close to the central area has continued to provide additional capacity in the immediate surroundings of downtown, thus encouraging the access by car and a more car dependent travel behavior.
Overall, still reduced efforts to promote alternative mobility, and small interventions to support mass transit, have been produced. In particular, the proposed interventions, even if entailing a new start in the direction of the integration of private and public transportation policies, lack of long term willingness to create lasting solutions, as part of a integrated strategy for real steady sustainable transportation in the region.

Long-term strategies for Bari
The experience of the last fifteen years of transportation (and parking) policies has demonstrated a generally failure to deal with the problem of reducing traffic congestion coherently. One feature is indeed missing, and this characterizes both approaches to transportation planning that have been described. This is the lack of a strategic vision for the development of transportation. Many interventions have been proposed, and part of them have been developed, bringing to contradictory orientations on the way to reshape the local transportation system.
Even in the most recent years, in which a number of apparently connected projects has inspired the process of transportation planning, elements of contradiction still exist. The establishment of a metropolitan planning organization that should inspire strategic solutions for the growth of the city has not completely solved the problem. The first interventions proposed by the new strategic MPO have in fact not always gone in the same direction of the solutions adopted. The new authority for strategic planning has highlighted several interventions to implement in the area. The need for further development of light rail projects and subway lines has been claimed. What is evident is the need to develop consistent strategies for sustainable mobility in the urban and metropolitan area, which include several packages of policies for each single problem, but that are designed coherently as part of a unique vision for a modern, efficient and sustainable city.
Among the priorities of such a plan is the upgrade of public transportation, with the investment in new mass transit

Bike paths and facilities increase the mode share for the “soft mobility” and reduce travel demand by car.



MARS-Bari forecasts of mode share under specific policies on the development of the transportation system.

solutions, e.g. subways and light rail systems, indeed. This should attract an increasing share of travelers, with frequent and reliable services that reach most destinations.
However, the improvement of transportation services also means a coordinated effort to support alternative mobility, with the extension and upgrade of pedestrian areas and bicycle paths, and their protection in designated intersection, and eventually with the use of barriers to separate motorized flows.
Additional efforts in order to make urban mobility more sustainable can be reached through the adoption of specific regulatory and financial policies, to support more environmental friendly solutions and off-peak trips, with disincentives for the "drive alone" travel solution.
As part of all these integrated strategies, parking policies play an important role, too.
Apart from supporting the access to transit solutions, through the construction of dedicated facilities in the proximity of transit terminals, they can be used as a flexible tool to reduce and moderate the access of cars to specific areas. The choice of the location and the size of the parking facilities, together with the policies with which parking lots are managed, become therefore extremely relevant for the success of the whole transportation strategy.
The availability of advanced tools for the simulation and modeling of the evolution of the transportation system, and of the interactions with the system of the activities in the urban area unveils important properties for the evaluation of the outcomes of such strategies.
Besides, integrated approaches for land use and transportation modeling help supporting the development of the strategic packages of interventions, with the estimation of the long-term results that derive from their implementation. The role and the possibilities offered in this field by the integrated approaches for long term strategic planning and modeling is discussed in the following section.

The simulation of parking policies through the use of integrated land use transportation modeling

In order to evaluate long-term strategies for transportation, the use of strategic models is particularly useful to simulate the joint development of land use and transportation. Land use transportation interaction models can conveniently simulate the interactions among the different subsystems of the territorial system, and their use has been successfully applied to test the long-term impacts of interventions on transportation infrastructure and services. In particular, the use of these models may constitute an important support for planning activities, and for the definition of packages of strategic policies for the future governance of the city.
MARS-Bari is a fast land use transportation interaction (LUTI) model that has been developed on the basis of the assumptions of the Metropolitan Activity Relocation Simulator (MARS) modeling system (Pfaffenbichler 2003).
The model was developed for applications on the metropolitan area of Bari, and it was already applied to test several scenarios of development in the area (Circella 2008). It is designed as a support tool for applications in strategic planning, and its simulations allow forecasting the future development of the city and of its metropolitan area with a time horizon of 30 years (in the current version of the model). The model is based on the assumptions of systems dynamics and works at a high level of spatial aggregation. It includes a transportation model and a land use model; the latter simulates the relocation of economic activities and of residences in the area of study. Feedback loops

among the sub-models allow taking into account the interactions among the changes over time in land use and the modifications in the transportation system and in travel behavior (and vice versa).
The transportation sub-model of MARS-Bari was designed in order to allow various testing of interventions on the transportation system. It simulates the travel behavior of the users and their mode share among all relevant means of transportation in the region (cars, motorcycles, public transport-railway, bus services, and "soft mobility" represented by pedestrians and bicyclists). Different scenarios involving the development of transportation can be tested in MARS-Bari. In particular, the long-term effects of transportation projects can be estimated in terms of their impacts on travel behavior, and of the other modifications they induce in the components of the system of activities and residences. The transportation model of MARS-Bari is therefore particularly suited to study the development of integrated strategies for transportation in the area, which include several interventions on the system in a framework of global vision for the future development of the city. The application may be of interest for the development of such strategies, defined as a combination of the different policies that were proposed, as described in this paper. It would allow testing the results of their implementation, and checking the consistency of the proposed solutions with the aim of reducing pollutant emissions and the overall impact of transportation on the environment. The transportation model of MARS-Bari allows evaluating the impact of such strategies on the travel behavior of users, and it estimates the mode choice of travelers depending on the availability of private vehicles in each household. The transportation model identifies four main travelers' groups, depending on their access to private vehicles, which is defined in terms of possession of a driving license, and respectively of a car or a motorcycle.
The effects of parking policies can be tested in the system through their impact on the friction factor for the use of car in the transportation and mode share sub-models. Specific projects of development in this field can be tested. Parking fee policies can be studied through the modification they determine on the attractiveness for the use of car. The friction factor for the use of car is defined in the model by the following equation:

$$f\left(t_{ij}^{car}, c_{ij}^{car}\right) = \sum_{k} t_{ij}^{kcar} * SV_{ij}^{kcar} + Z_{ij}^{car} \quad (1)$$

In which all different times and costs related to the use of car for a specific trip are accounted for. The availability of parking in each zone of the system of analysis affects the use of car through the total parking capacity for the area, and the time needed to access a parking spot in the specific time of the day. Moreover, the model allows testing specific parking policies, as the adoption of differentiated parking fee structures for the different parts of the day (e.g. for peak/off-peak), and differentiated fares for long term/short term parking. A subjective valuation factor SV_{ij}^{kcar} is used in the model to correct each different amount of time associated with the use of cars for the subjective perception e.g. of the walking time to access the car, the time spent in the vehicle, and the time spent to find a parking lot. A different subjective valuation factor is introduced for each different part k of the trip:

$$SV_{ij}^{kcar} = a + b * e^{c * t_{ij}^{kcar}} \quad (2)$$

The term Z_{ij}^{car} measures the perception of costs in the friction factor to use the car mode to travel, and it includes all costs associated with the use of car. Similar functions are adopted for the use of motorcycles, with the important difference that parking costs are usually absent (as in the reality of the transportation network in Bari) for motorcycles, and that parking time is sensibly shorter. The flexible cost structure adopted in the model allows testing many other hypotheses related to the use of cars, as road pricing or the development of new transit links, which makes the use of MARS-Bari particularly well suited to study specific interventions on transportation.
In the author's opinion, the development of transportation strategies in the area would definitely benefit from the simulations with this model, as a way to test the outcomes resulting from their implementation and from their future interactions with the other elements of the system. The model MARS-Bari has been already applied on several scenarios involving the adoption of interventions on transportation. The GIS interface of the model (as shown in the figure) allows the users to represent the results of the simulation graphically, e.g. in terms of levels of travel demand for each zone, mode share, etc. Additional modules of MARS-Bari allow estimating traffic congestion in the different areas, and the levels of pollutant emissions due to transportation activities, in order to support analysis on the environmental impact and on the (un)sustainability of the system. The application of the model to specific scenarios that test transportation strategies with relevant modifications on the parking system is currently under development. The availability of the results of these simulations is expected to contribute actively to the discussion on how to better address the development of the parking strategies. More generally, they will contribute to the formulation of comprehensive transportation strategies, in order to integrate the local interventions on the parking system with the development of mass transit and the other interventions on the transportation system, in the framework of an improved and environmental-friendly transportation system.

Conclusions

In this paper, the role of parking facilities in urban and metropolitan areas has been discussed, with the aim of analyzing how parking facilities can nowadays play an important role in the definition of packages of policies for sustainable transportation. Parking infrastructures are an important element of the transportation system, indeed. They are a necessary support for private mobility, and a major element of more complex multimodal systems of transportation. In the paper, the organization of parking facilities is discussed from the viewpoint of the enhancement of sustainable transportation solutions. The contribution is based on the awareness that the determination of the optimal amount of parking space to provide in an urban settlement is not a trivial task. The supply of insufficient parking space has in fact negative effects on the environment, especially in presence of poor services offered by mass transportation, due to the increase in congestion on the road network, and the consequent increase in pollutant emissions. On the other hand, an overcapacity of parking facilities contributes to increase congestion, since it induces additional travel demand and increase the attractiveness of private vehicles. Moreover, in the long run, low density settlements with huge parking space implies less pedestrian and transit-friendly environments, with an overall decrease of environmental quality.

In the paper, the topic of the definition of parking policies in high-density urban areas is discussed with reference to some recent projects implemented in the city of Bari (Italy). Based on the analysis of the outcomes of such projects, the discussion moves to to the potential integration of parking policies into more comprehensive strategies for urban transportation.

The possibility of estimating the results of the implementation of such integrated strategies in long-term scenarios is then discussed with regard to the use of the land use integrated model MARS-Bari.

This is a way to estimate the long-term outcomes of the implementation of such policies, and support the definition of the best suited interventions to include in such strategy.

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Notes

[1] Definition provided by the Merriam-Websters online dictionary.

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Le immagini di pag. 18, 19, 20 e 25 sono dell'autore. I render di progetto a pag. 23 e 24 sono tratte da Metropoli Terra di Bari, 2008, quello a pag. 17 è tratto dal sito web http://www.urbanfile.it.