Territorial impacts of innovative transport solutions

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Territorial Impacts of Innovative Transport Solutions

Fulvio Silvestri, Pierluigi Coppola**

Abstract

In recent years interest in urban mobility has grown considerably, not only due to the local increase in negative externalities generated by transport, but even because recent technological innovations are offering effective solutions especially in urban context. In particular, the introduction of Connected and Automated Vehicles (CAVs) could radically change the mobility scenario allowing, on the one hand, a widespread diffusion of vehicles in shared mode that feed the stations of the mass rapid transit, improving the attractiveness of Public Transport (PT), and on the other, the implementation of Travel Demand Management (TDM) measures on large areas of the most densely urbanized (and congested) territory of a city, without take the risk of reducing accessibility and creating social exclusion.

The present study aims at evaluating, through a system of Land-Use Transport Interaction (LUTI) models, the impacts on transport demand and on population and activities location, deriving from the implementation of policies oriented to both enhancing PT and restricting the individual use of the car. The case study analyzed is represented by the urban area of Rome. Several scenarios have been simulated and compared by means of (economic, environmental and social) sustainability indicators. Preliminary results show that the improvement of PT services, combined with the introduction of restricted traffic areas and pedestrian zones, induce not only a significant modal shift towards more sustainable transport modes, but also a limitation of the urban sprawl.

1. Introduction

In the past, the problem of diverting car trips towards Public Transport (PT) modes has been addressed through increasing integrated PT services ("pull" policies) and by access restricting and/or pricing for private cars ("push" policies). The impacts of such policies have in some cases been effective, but have been limited by economic and social constraints. In fact, due to limits imposed generally by operating costs, PT services cannot be so capillary and frequent, to

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be more convenient than driving by car. On the other hand, the implementation of pricing policies that limit the access by car to some areas and streets is seen as unfair, since it might create unequal accessibility opportunities, and in some cases segregation conditions (less advantages) for those population segments that cannot afford to own a private car or to pay for a taxi.

However, the potential offered by advanced technology allows nowadays (and increasingly it will do in future) to implement effective Travel Demand Management (TDM) measures to improve the quality of urban mobility. It is widely believed that the deployment on the roads of electric Connected and Automated Vehicles (CAVs), will profoundly change the urban mobility scenario. In particular, PT and car-sharing services could face a significantly reduction of operating costs, allowing widespread distribution of services at affordable prices (also in areas with low-demand density). In the literature, preliminary studies have shown the potential impacts of autonomous driving, both on the supply of urban mobility services and on the demand side. However, it is not yet clear what impact the new supply of PT services (including shared mobility) and some disruptive TDM policies (e.g. large-scale car-free zones) could have on economic growth and urban form development.

The new challenges for decision-makers and researchers in this domain would be that of identifying what policies to put in place in order to avoid that the technological shift will result, on the one hand, in increasing travel distances, in turn increasing congestion level, and on the other hand, in more disperse land-consuming urban development.

2. Research objectives and methodological approach

This research aims at testing the sustainability of future integrated land use and transport scenarios, which provide for increasing diffusion and capacity of PT and vehicle-sharing solutions combined with TDM measures, with an application to the urban area of Rome. To this aim, a system of Land-Use Transport Interaction (LUTI) models has been applied to understand interdependence of key planning variables such as travel behavior, transport supply, economic activities and inhabitants' location. The models represent the behavior of both dwellers and transport users and how they react to changing conditions. A set of indicators has also been defined to systematically evaluate and compare alternative future scenario and to assess to what extent different policies achieve sustainability in terms of transport performances and environmental impacts.

The work consists of the following phases:

1. Identification of the current and the future reference scenario, through the examination of strategic guidance documents with regard to the study area.

2. Design of future analysis alternative scenarios, according to the different hypotheses of development of the transport system.
3. Simulation of the scenarios by means of an integrated LUTI model system (Coppola, Nuzzolo, 2011), the so-called STIT, which is based on a system of behavioral models that simulate: the travel choices made by the users of the transport system; the location choices of the residential zone made by the population; the location choices of business made by economic subjects (mainly private firms and commerce).
4. Analysis of the results and comparison between the scenarios, using a set of economic, environmental and social sustainability indicators.

The reciprocal interactions between mobility and location choices by residents and firms is simulated through a stochastic equilibrium model which, solved through the *method of successive averages (MSA) algorithm*, provides the configuration of the land use-transport system in which the variables are mutually consistent. As output, the STIT models returns: the spatial distribution of the population, subdivided into five socio-economic categories of individuals, consistent with the national census classification (ISTAT), i.e. high-income worker, mid/low-income worker, high school student, university student, other (older than 14 years); the spatial distribution of economic activities, by a proxy of the employees in commercial activities, employees in private services, employees in public services; the Origin-Destination matrix of the journeys by purpose of the trip (work, study, other) and by mode of transport (cars, motorcycles, PT, walk/bike).

3. Application to the urban case study of Rome

The study area corresponds to the urban area of Rome. The business-as-usual scenario (BAU) for the development of the urban and the transport system, was built up using the following strategic guidance documents: the municipal urban masterplan *Piano Regolatore Generale* (PRG, 2008); preliminary documents of the regional transport plan *Piano Regionale della Mobilità, dei Trasporti e della Logistica* (PRMTL, 2014); the municipal transport plan *Piano Generale del Traffico Urbano* (PGTU, 2015); preliminary documents of the metropolitan transport plan *Piano Urbano della Mobilità Sostenibile* (PUMS, 2017). The BAU is a long-term future scenario, with a time horizon of 2030, which considers: an increase of the population up to about 3 million residents (STATUS, 2016); the completion of the interventions on the housing stock proposed by the PRG, and the completion of the so far *approved infrastructure projects*. The PRG foresees an increase in Gross Floor Area (GFA) for residential use of 12% compared to the current scenario (CS), for a total of 11,642,183 m² of new houses. Interventions on the real estate stock are concentrated mainly in areas

outside the highway ring which surround the city, in fact around 80% of the new residences will be built in the outer crown. With respect to the interventions on the transport system, not all the infrastructure projects envisaged by the plans have been considered, both at the municipal and regional level, but only those that will be more realistically completed by 2030 and that will have a significant impact on the transport supply system.

In the alternative scenarios (AS), *additional infrastructure projects* have been taken into consideration, which are considered necessary for the resolution of critical issues in some zones of the study area. It is also assumed the widespread deployment of Intelligent Transportation Systems (ITS) and electric CAVs in shared mode (including both driverless shuttles/minibus and driverless cars), that will serve as feeder service for the mass rapid transit (tram and metro) network from the areas with low demand density and/or to the areas in which a TDM measure is implemented. In fact, the advent of new technologies opens the doors to strict (and equally ambitious) management interventions in terms of regulation of transport demand (particularly on private vehicles). In particular, the effects of two different policies for moderating the individual use of private vehicles were examined: the Limited Traffic Zone (LTZ) and the Car-Free Area (CFA). The former provides the restriction for the incoming trips of cars into these zones, while the latter extends the limitations to motorcycles and also to the outgoing trips from those zones. Different levels of extension of the area subject to these two kinds of traffic control are considered. The possible extensions are: the area "AS IS", that refers to the LTZ currently in force in the historic center of Rome; the area "AF", that considers the zones inside the railway ring; the area "TO BE", that consists in a larger portion of the most densely urbanized and congested territory.

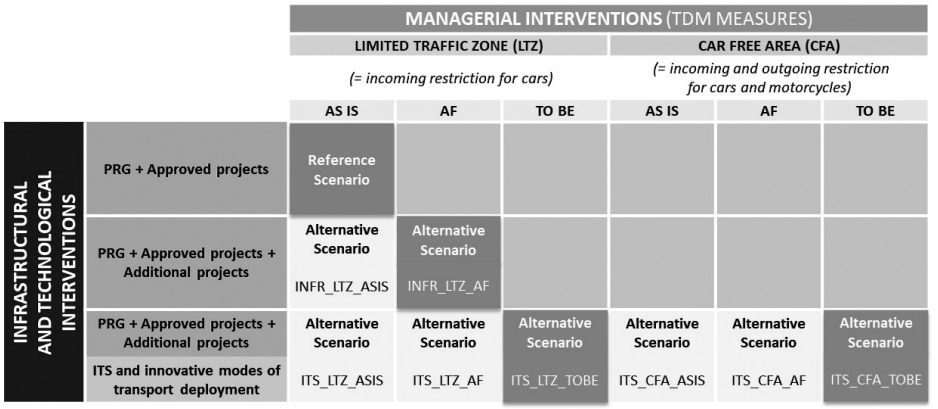
The combination of the aforementioned different types of intervention led to several alternative scenarios, identified from the possible intersections of the matrix reported in Figure 1. In the following of this paper only the results of the simulations of the scenarios highlighted in green are reported.

4. Key findings

The simulation of the BAU scenario shows an uncontrolled spread of the population in peripheral areas of the city (urban sprawl): compared to the current scenario, the population in the inner areas declines while it increases by 30.8% in the outer ring. The model therefore estimates that almost a third of Rome's population (931,498 out of 2,991,562 inhabitants) will reside outside the highway ring, mainly due to the new residential development scheme proposed by the PRG.

In the proposed alternative scenarios, in which the widespread diffusion of new generation vehicles and the extension of the LTZ/CFA is assumed, it is

Figure 1 – Matrix of interventions and scenarios to simulate



possible to notice that the phenomenon of urban sprawl is reduced. The area subject to TDM measures is, in fact, highly attractive for the residents as it is shown for instance, in Figure 2.

The direct comparison of all four scenarios allows a better understanding of the settlement dynamics and the alterations of the mobility demand. With regard to the impacts on land use, it emerges that in the AS there is a reduction in the population density of the fourth and fifth crown, in favor of the central crowns. That is, the sprawl of the population on the territory is significantly reduced, compared to what occurs in the RS.

As regards the demand for mobility, it can be observed that (Figure 3): in the "INFR_ZTL_AF" scenario, where only infrastructural interventions are foreseen, private vehicles remain the most used mode of transport, even under the assumption of extending the LTZ to the entire area bounded by the railway ring; in the other two alternative scenarios, in which the widespread distribution of CAVs services is also assumed, the use of the car decreases from the reference value of 54% to 32% or 22% depending on the extension (up to the third crown) of a LTZ or a CFA.

It is precisely in these scenarios, finally, that the best results can be achieved in terms of environmental sustainability, with reductions in energy consumption and CO2 emissions between 43% and 54% (Table 1).

5. Conclusions

The housing stock development foreseen by the municipal urban masterplan of the city of Rome (PRG) in the peripheral zones of the urban area, appears to be not aligned to the transport infrastructural interventions, which, from our

Figure 2 – Map of variations of the localization of residents; Index number of population density

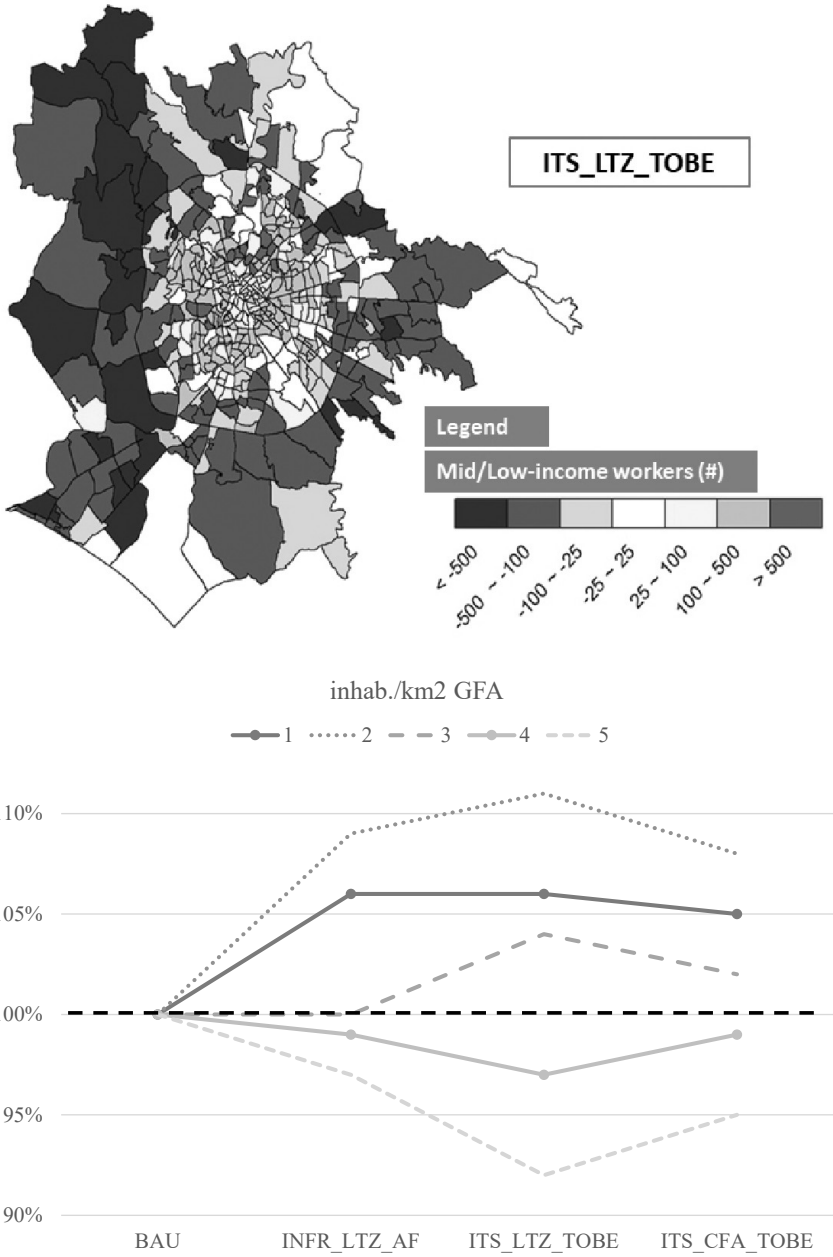


Figure 3 – Modal split variations in all future scenarios

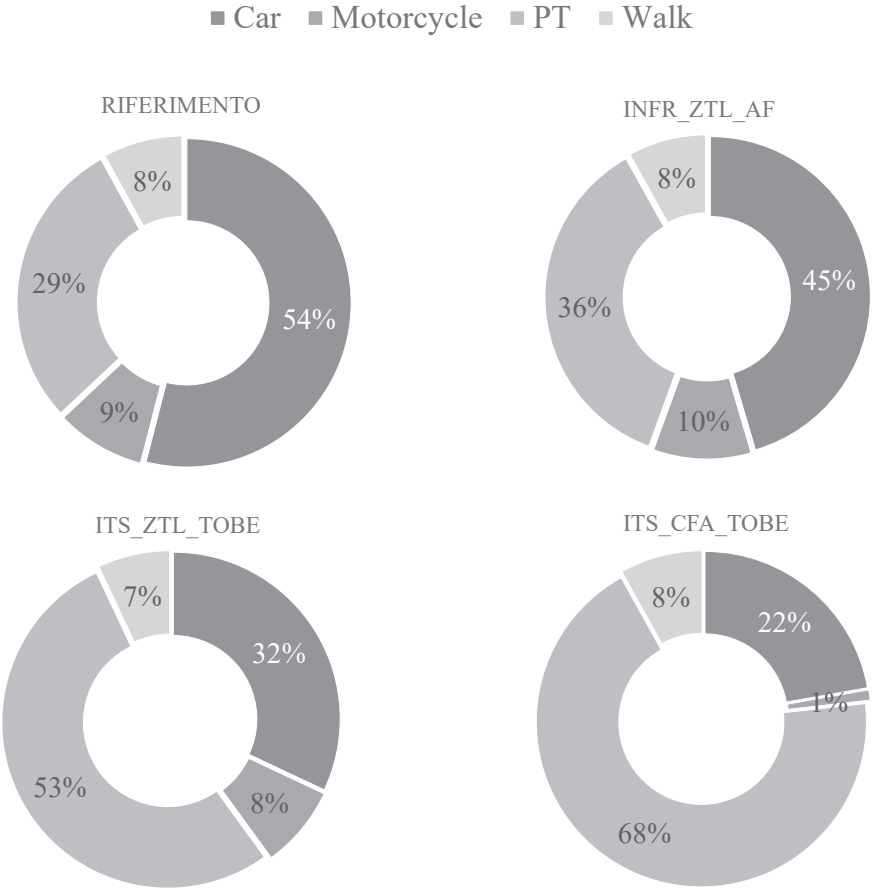


Table 1 – Economic and environmental sustainability indicators (values per rush hour)

Scenario	*Mileage vehicles-km*	*Energy consumption GJ*	*CO_2 emissions t*	*Change %*
BAU	3.562.479	16.459	312	-
INFR_LTZ_AF	3.003.994	13.879	263	-15,7%
ITS_LTZ_TOBE	2.026.092	9.361	178	-43,1%
ITS_CFA_TOBE	1.643.584	7.593	144	-53,9%

analysis, resulted to be inadequate in terms of access to the urban and regional mass rapid transit network, and lead residents and city-users to unsustainable travel choices (i.e. increasing car usage).In fact, the simulation of the BAU scenario shows an increase of the urban sprawl with increasing travelled distances between residence and workplaces without access to the mass rapid transit network (tram and metro), which favors a car-oriented mobility with a consequent increase of pollutants emissions.

In the simulated future alternative scenarios, additional infrastructural interventions have been assumed, aimed at improving accessibility and reducing the general cost of travel by public transport. This allows for a slight reduction of the urban sprawl; however, the analysis shows that there is not a substantial reduction of the negative externalities generated by transport: private vehicles remain the most used mode of transport, even assuming an extension of the Limited Traffic Zone (LTZ) for not-residents' vehicles. On the other hand, a profound change in the modal split occurs when a widespread deployment of new technologies coupled with the implementation of very strict TDM policies, such as the institution of a Car-Free Area (CFA), is assumed. The widespread diffusion of CAVs in shared mode and as PT feeder services encourages a more intensive use of collective transport modes, even in areas with low demand density. With regards to land use, it is observed that the extension of the area subject to TDM measures tend to limit the urban sprawl. In conclusion, the improvement of the collective transport services combined with large-scale restricted traffic areas and pedestrian areas, allowed by the innovative and shared mobility solutions, may induce a significant modal diversion from private vehicles towards the collaborative consumption of more sustainable modes of transport, and induce a limitation of the urban sprawl. The simulations highlight also some remarkable results in terms of economic and environmental sustainability.

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Impatti territoriali delle modalitàdi trasporto innovative

Sommario

Negli ultimi anni è cresciuto considerevolmente l'interesse per la mobilità urbana, non solo per l'aumento delle esternalità negative generate dai trasporti, ma soprattutto perché le recenti innovazioni tecnologiche stanno offrendo soluzioni particolarmente efficaci proprio nei contesti urbani. Nello specifico, l'introduzione di veicoli a guida autonoma e connessa (Connected and Automated Vehicles, CAVs) potrebbe cambiare radicalmente lo scenario consentendo, da una parte, una diffusione capillare di veicoli in modalità condivisa che alimentano le stazioni del trasporto rapido di massa, migliorando l'attrattività del Trasporto Pubblico, e dall'altra, l'implementazione di politiche di controllo e moderazione della domanda di trasporto (Travel Demand Management, TDM) su aree estese del territorio più densamente urbanizzato (e congestionato), senza il rischio di ridurne l'accessibilità e creare esclusione sociale.

Il presente studio si propone di valutare, attraverso un sistema di modelli di interazione Trasporti-Territorio (Land Use Transport Interaction, LUTI), gli impatti sulla domanda di mobilità e sull'uso del suolo, derivanti dall'attuazione di misure volte al potenziamento dei servizi di Trasporto Pubblico e alla restrizione dell'utilizzo delle automobili. Il caso di studio analizzato è rappresentato dall'area urbana di Roma. Diversi scenari di sviluppo della città sono stati simulati e confrontati attraverso un insieme di indicatori di sostenibilità economica, ambientale e sociale.

I risultati mostrano che con il miglioramento dei servizi di trasporto collettivo, combinato a ZTL e aree pedonali diffuse su larga scala, è possibile ottenere non solo una significativa diversione modale (modal shift) verso alternative di trasporto più sostenibili, ma anche una limitazione del fenomeno di dispersione urbana (urban sprawl).