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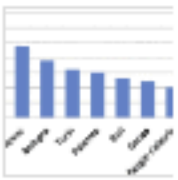

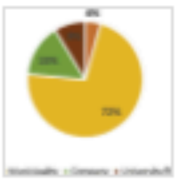

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Smart mobility in Italian metropolitan cities: A comparative analysis through indicators and actions

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Highlights

- The paper proposes a methodology for assessing smart urban mobility.
- The Smart Mobility concept is defined through three evaluation categories.
- Through analysis in the field, Smart Mobility initiatives are identified.
- Smart Mobility indicators are defined for measuring urban mobility performance.
- The analysis of Smart Mobility levels in Italian Metropolitan cities is carried out.

Abstract

As a consequence of the spread of the Smart City paradigm, many cities are implementing Smart Mobility initiatives that are more suitable than other fields of investment for the dissemination of new technologies. This article is an empirical study about 11 Italian

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ABSTRACT

As a consequence of the spread of the Smart City paradigm, many cities are implementing Smart Mobility initiatives that are more suitable than other fields of investment for the dissemination of new technologies. This article is an empirical study about 11 Italian metropolitan cities, to investigate whether and to what extent the Smart City paradigm, applied to the mobility sector, is able to enhance the efficiency and liveability of urban areas. Through a set of parameters and the grouping of the main Smart Mobility initiatives, this study seeks to answer the following research question: as a result of the Smart City approach, have the Italian metropolitan cities enhanced their mobility system? This study highlights the fact that the application of the Smart City paradigm has had different effects on urban mobility systems, as the potential application of the model in question can be limited by the poor starting position of some cities. Indeed, in cities with a well-functioning mobility system, ICTs are a means to improve the efficiency of the transport system, while in metropolitan contexts where there is a lack of transport infrastructure, the use of new technologies becomes only a label rather than being integrated into urban policies.

1. Introduction

In the last few years the topic of the Smart City has been widely studied. At the same time, many cities have also adopted such a "paradigm" through experimental applications, thus contributing to the innovation and accessibility of urban services. To date, several definitions of Smart City have been developed, each of which has highlighted specific aspects and features (Albino, Berardi, & Dangelico, 2015; Batty et al., 2012; Caragliu, Del Bo, & Nijkamp, 2011; Fistola, 2013; Giffinger et al., 2007; Harrison et al., 2010; Manville et al., 2014). Some definitions highlight the key role of ICTs, while others radically criticize the "technocentric" vision (2015, Hollands, 2008). Finally, others view the Smart City as an accessible, sustainable, cohesive and inclusive city, integrating the "technocentric" vision with aspects related to social capital, environmental sustainability, urban services, etc. (Papa, Gargiulo, & Galderisi, 2013; Papa, Gargiulo, Cristiano, Di Francesco, & Tulisi, 2015). With the use of ICTs, "smart" solutions can improve not only the performance of urban services for citizens, firms and city users, but also the quality of life and accessibility to infrastructural facilities (DPS (Dipartimento per lo Sviluppo e la Coesione Economica) (2014)). All these aspects are included in the model of the Smart City (Giffinger et al., 2007), consisting of six dimensions – Environment, Governance, Economy, People, Living and Mobility.

Among the above-mentioned dimensions, due also to technological advances and the interest of large enterprises in the transport sector, many cities are investing in Smart Mobility. Although there are several meanings and interpretations of the Smart Mobility concept, it can be defined as a network system mainly characterized by connections, both digital and physical, in order to satisfy people's needs; use of appropriate technologies, to enhance performance and attractiveness of the mobility system; sustainability, to reduce the need to travel and hence reduce energy consumption and carbon emissions, according to previous studies on this issue (Lam & Head, 2012).

Owing to the considerable benefits (also financial) provided by ICT use, Smart Mobility is considered the main option to seek more sustainable transport systems (Benevolo, Dameri, & D'Auria, 2016; Francini, Palermo, & Viapiana, 2016; Staricco, 2013). Several studies have tried to examine the overlap between the concepts of Smart Mobility and Sustainable Mobility (Lyons, 2016; Pinna, Masala, & Garau, 2017; Van Nunen, Huijbregts, & Rietveld, 2011). Lyons (2016) identifies four possible relationships between Smart Mobility and Sustainable Mobility through Venn diagrams and shows that two separate paradigms for urban mobility are «nonsensical», believing that «smart and sustainable mobility need to be brought together». For Pinna, Masala &

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Garau (2017) Smart Mobility is a more dominant paradigm than sustainable mobility and it is considered «an integrated system instead of comprising several projects and actions all aimed at sustainability». Finally, others (Papa & Lauwers, 2015; Staricco, 2013) have shown that Smart Mobility and their use of ICTs could play a potential role in the sustainable development of transport systems only if the highest quality and quantity of information is converted into sustainable behavior by citizens.

In conclusion, all the researchers state that since the transport sector contributes significantly to lowering the environmental quality of the city, Smart Mobility is first and foremost Sustainable Mobility. Therefore, if Smart Mobility means principally a widespread use of ICTs in the transport system, at the same time the integration between “smartness” and sustainability of urban mobility can be achieved through the use of devices and innovations that make the transport system more compatible with the urban environment (e.g. reducing emissions, using alternative fuel sources, favoring soft transport systems, etc.). Some researchers highlight the fact that the use of ICTs in Smart Mobility is not only aimed at making urban mobility more sustainable, but is a useful means both for transcending distance and optimizing traffic flows and, at the same time, collecting citizen feedback about liveability in cities and quality of public transport services (Benevolo et al., 2016; Lyons, 2016). However, it is not only the massive use of innovative technologies which through a technocentric approach (Papa & Lauwers, 2015) makes the mobility system more appropriate to deal with the challenges of inclusiveness, accessibility and sustainability. In other words, if technology allows us to improve transport efficiency and reduce its impact on the environment, it is also true that only a harmonious and integrated combination of multiple aspects such as accessibility, sustainability and ICTs can make a mobility system suitable to support the development of urban activities, taking into account the needs of its users (Joumard et al., 2010).

Therefore, it can be assumed that three categories - accessibility, sustainability and ICT – encapsulate the main characteristics that Smart Mobility should have, according to the studies examined so far. Going beyond the many labels used to define Smart Mobility, the best application of technology is that able to make urban mobility more sustainable. Indeed, Smart Mobility has increasingly played a key role, especially in large cities where there is the highest concentration of activities and population and hence a greater need to have a widespread and effective transport network in order to guarantee high levels of accessibility. At the same time, it is necessary in large cities to define policies and strategies capable of reducing the impact of transport and mobility on the environment and climate (i.e. air pollution, noise pollution, etc.). Moreover, from the brief scientific framework provided, it is evident that local administrators have been increasingly keen on innovation and investing human and economic resources in the Smart Mobility sector in order to modernize their infrastructure network, stimulate economic growth and create employment (McKinsey & Company, 2015; Navigant Research, 2015). In Italy large cities are known as metropolitan cities, as defined by Law 56/2014 “Provisions on Metropolitan Cities, on Provinces, on unions and mergers of Municipalities”. Italian metropolitan cities account for about 30% of the population, 36% of GDP and a substantial proportion of the country's tax revenues, as well as public and private investments. This limited amount of data is sufficient to appreciate the economic and social importance “of the new long-awaited administrative subjects from the best part of the country” (Papa, 2016) to enhance accessibility to urban services and increase sustainability, especially concerning the transport system.

In this context, through the analysis of the Smart Mobility initiatives and the definition of synthetic indicators of urban mobility, this paper aims to ascertain whether and to what extent the Smart Mobility concept is contributing to the efficiency, sustainability and quality of life in 11 Italian metropolitan cities.

The paper is organized as follows: the second section describes the research methods adopted for this study; the third describes the main demographic and infrastructure characteristics of the Italian cities under investigation; the fourth section discusses the main results of the analysis; finally, the last section offers some reflections on the Smart Mobility status of metropolitan cities in Italy.

2. Materials and methods

Within the framework of an empirical study developed by the Department of Civil, Architectural and Environmental Engineering (University of Naples Federico II) between 2014 and 2016, this analysis concentrated on Italy's 11 metropolitan cities. The sample was chosen for two reasons: according to the empirical evidence, the main "smart" initiatives are implemented in the most urbanized areas within a metropolitan area, as mentioned by the report "Mapping Smart Cities in the EU" (Manville et al., 2014), which shows a strong correlation between the urban scale and the implementation of "smart" urban policies. Moreover, the available parameters at metropolitan level are currently still too few to provide a comparison between these new Italian territorial contexts. According to the geographical areas defined by the Italian National Institute of Statistics (ISTAT), the 11 cities were structured into three classes (Fig. 1):

- Northern metropolitan cities: Turin, Milan, Genoa and Bologna;
- Central metropolitan cities: Florence and Rome;
- Southern metropolitan cities: Bari, Naples, Reggio Calabria, Palermo and Catania.

In the last ten years, extensive research has sought to assess whether and to what extent cities are “smart” by comparing them with one another. Most of these studies have defined synthetic indicators to measure urban smartness (e.g. Giffinger et al., 2007) and, more recently, one of its dimensions, which is Smart Mobility (e.g. Garau et al., 2015). For Albino, Berardi & Dangelico (2015) and Vanolo (2014), such indicators are unable to measure smartness effectively among urban contexts since their use entails a lack of information. Indeed, even if indicators are a powerful means for describing complex phenomena and supporting decisional processes in order to define effective strategies and urban actions, they do not measure the social, demographic and cultural differences among the cities (Kitchin, Lauriault, & McArdle, 2015).

From this perspective, although the present study proposes the use of synthetic indicators, through geographical clustering that allows identification of different socio-economic and cultural urban contexts of development in Italy, this kind of research could be further implemented by better interpretation of the synthetic indicators and of the initiatives implemented in each Italian metropolitan city.

The procedure for such analysis has been divided into the following phases:

1 Overview of the metropolitan cities and their mobility system;
2 Selection of Smart Mobility initiatives for each metropolitan capital city;
3 Classification of selected initiatives based on types of action;
4 Identification of categories for each type of action for analyzing initiatives;
5 Definition of a set of parameters for each category for auditing the status of Smart Mobility in the Italian cities; and
6 Comparison between the Italian metropolitan cities regarding initiatives and parameters.

After analyzing the main demographic, territorial and mobility features for each city, screening of the most significant ongoing Smart Mobility initiatives was subsequently carried out. Based on criteria established by Papa, Gargiulo, and Battarra, (2016), this study used the level of technological innovation, replicability in other geographical

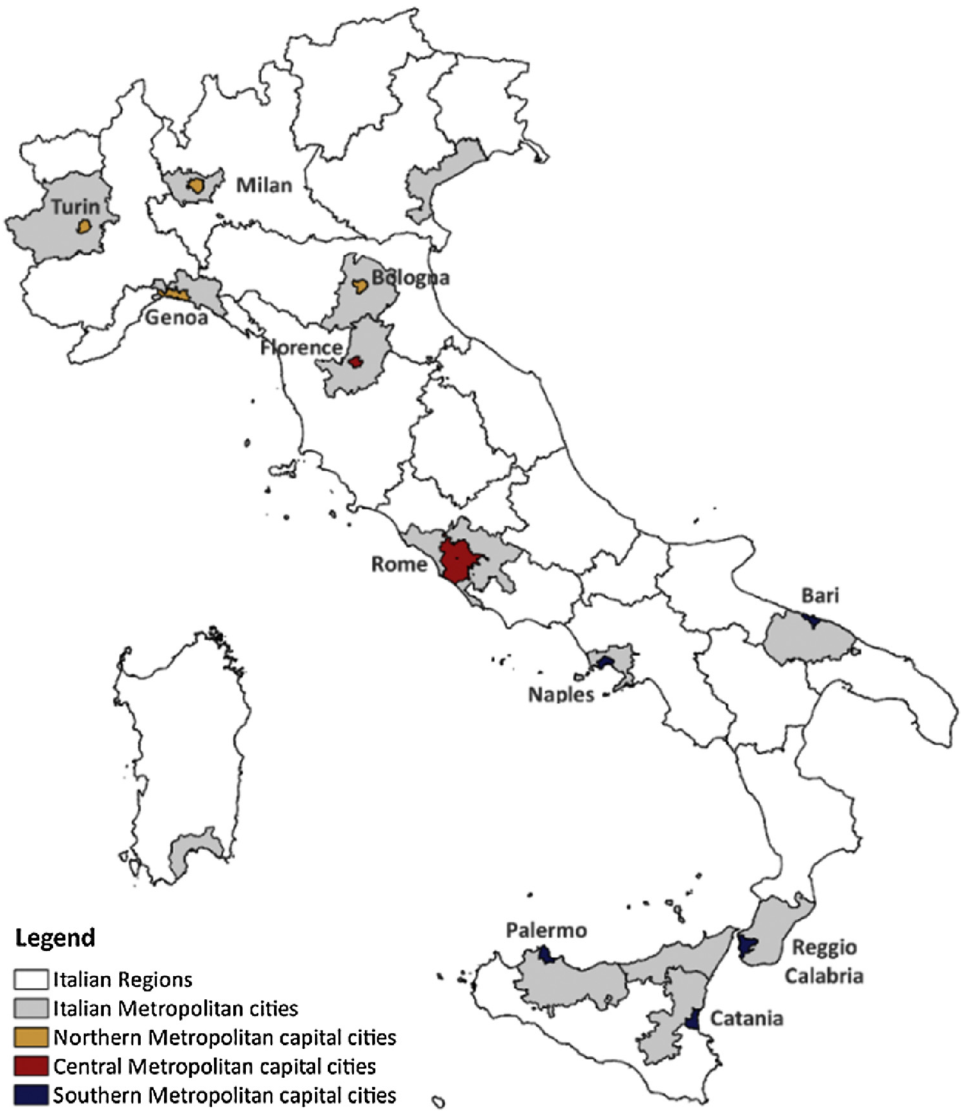

Fig. 1. Map of Italian metropolitan cities.

Table 1
Types of Smart Mobility actions and corresponding categories.
(Source: By Authors)

Types of Smart Mobility actions	Categories
A. Creation of new mobility infrastructures	Accessibility
B. Improvement of public transport	
D. Reinforcement of the car park system	
C. Promotion of soft mobility	Sustainability
F. Promotion of mobility sharing	
G. Promotion of e-mobility	
E. Logistics innovations	ICT
H. Implementation of info-mobility services	
J. Mobility platforms	
K. Mobile apps and other technology products	

contexts and the implementation level of the initiative. Such initiatives were selected by examining several indirect sources (i.e. instruments for urban and territorial government, web sites, publications). The initiatives were then classified into ten types of actions, as summarized in Table 1.

In order to have an overview of Smart Mobility selected projects, in the third phase the related types of actions were grouped into three categories: sustainability, accessibility and ICT. For each category a definition was conceived for assigning each initiative to a category (Table 1):

- *Accessibility*: initiatives that aim to enhance the ability of places to be reached and guarantee safe and affordable transport for the urban community;
- *Sustainability*: initiatives that preserve the natural environment and promote the use of renewable energy resources and advocate the conservation of non-renewable ones; and
- *ICT*: initiatives that can be termed Intelligent Transport Systems (ITS) and have both the capability to improve the efficiency of the urban system and its impact on user behavior.

In the fifth step, a set of parameters was defined for each of the above categories. In particular, 28 parameters were chosen (Garau et al., 2015; Gillis, Semanjski, & Lauwers, 2015) and were divided into the three categories according to their definitions (Table 2). Their selection aims to measure the status of urban mobility in the metropolitan cities. The relative data were collected by consulting the ISTAT database from 2014, a year which, according to the available data, allowed the study to consider the implementation period of the initiatives selected. In order to evaluate the urban mobility condition in the Italian cities, for each parameter a benchmark was identified through its

Table 2
Parameters selected for the three categories.
(Source: ISTAT)

Category	ID	Parameter	Unit
Accessibility	A1	Public transport demand	No. passengers/inh.
	A2	Public transport supply	No. seats*km/inh.
	A3	Public transport lanes	km/100 km^2
	A4	Bus stop density	No. stops/km^2
	A5	Rail network	km/km^2
	A6	Rail network stops	No. stops/km^2
	A7	Toll parking	No. stalls/1000 vehicles
Sustainability	S1	Ecological buses (electric, natural-gas, LPG)	No. eco-buses/ 100,000 in..
	S2	Pedestrian zones	m^2/100 in..
	S3	Restricted traffic zones	km^2/100 km^2
	S4	Cycle lanes	km/100 km^2
	S5	Ecological cars (electric, natural-gas)	No.eco-cars/100,000 in..
	S6	Car sharing demand	No. users/1000 in..
	S7	Car sharing supply	No. available vehicles/ 100,000 in..
	S8	Bike sharing supply	No. bikes/10,000 in..
	S9	Bike sharing density	No. stations/100 km^2
ICT	ICT1	Road traffic signal systems	No./km^2
	ICT2	Variable message sign	1 or 0
	ICT3	SMS for traffic alerts	1 or 0
	ICT4	Electronic parking payment systems	1 or 0
	ICT5	Applications for mobile devices	1 or 0
	ICT6	SMS for public transport information	1 or 0
	ICT7	Electronic bus stop signs	1 or 0
	ICT8	Electronic travel tickets	1 or 0
	ICT9	Electronic travel ticket by mobile devices	1 or 0
	ICT10	Information on routes, schedules, times	1 or 0
	ICT11	LPT travel planner	1 or 0
	ICT12	Travel tickets online	1 or 0

average value, calculated as follows:

$$\overline{x_i} = \frac{\sum_{j=1}^{n} x_{ij}}{n}$$

With this value, it was possible to make a comparison between the different cities using suitable graphic representations of the parameters. The analysis was carried out only for the categories accessibility (A) and sustainability (S), as the ICT parameters are defined by dichotomous ones and do not provide more information than the analysis of the initiatives. Furthermore, after normalizing parameters through the Z-score standardization, a synthetic indicator for each category – I_A for accessibility and I_S for sustainability - was defined as a geometric mean value of corresponding standardized parameters A_i and S_i using the following formulas (1) (2):

$$I_A = \frac{\sum_{i=1}^{n} Ai}{n} \tag{1}$$

$$I_S = \frac{\sum_{i=1}^{n} Si}{n} \tag{2}$$

In the last step, through the comparison of results obtained from initiatives and indicator analysis, the Smart Mobility status of Italian cities was identified. The analysis highlighted the weaknesses of each city, but also gaps among them.

3. Italian metropolitan areas and their capital cities: demographic features and mobility

The Italian metropolitan cities are very heterogeneous in terms of both population size and area, as well as levels of wellbeing and socio-economic development and, more generally, the extent of urban infrastructure (e.g. ARUP, 2013; Censis, 2014; DARA (Dipartimento per gli Affari Regionali e le Autonomie) (2017); De Paoli, 2016).

Therefore, in order to consider such heterogeneity, each parameter was benchmarked to variables, such as urban area (km^2) or inhabitants. It was thus possible to make a comparison between completely different urban contexts.

Furthermore, this heterogeneity was taken into account during analysis of the results in order to highlight the differences among all the cities. By referring just to demographic (Table 3) and infrastructure aspects (Tables 4 and 5), ISTAT data show that in 2016 the population of the 11 capital cities was about 9,000,000 (15% of the whole Italian population), while that of the metropolitan areas was about 20 million (33% of the Italian population).

The cities vary greatly as regards population and density: Rome, for example, has over 2,800,000 in.abitants while Reggio Calabria has about 555,000. Naples has the highest density with over 8000 in.ab./km^2, followed by Milan and Turin. The population share of the capital city compared to the metropolitan area (Fig. 2) varies between the maximum value of Genoa, where about 70% of the population is concentrated in the capital, and Bari (26%). Average population growth in the last decade between the two censuses has recorded an increase of about 3.4%, which corresponds to about 690,000 in.abitants.

The unbalanced distribution of the population, in addition to determining the concentration both of inhabitants and primary activities in the capital cities, may explain some significant additive phenomena associated, in turn, to significant flows of users impacting on the mobility system. Analysis of vehicle fleet data (Table 4) shows that the number of cars related to the population experiences small oscillations

Table 3
Population, area and density of the metropolitan cities.
(Source: ISTAT)

City	Population (2016)		Capital City [km^2]	Metropolitan area [km^2]	Capital City density [inhab./km^2]	Metropolitan area density [inhab./km^2]
	Capital City	Metropolitan area				
Rome	2,864,731	4,340,474	1,287.36	5,363	2,225	809
Milan	1,345,851	3,208,509	181.67	1,576	7,408	2,036
Naples	974,074	3,113,898	119.02	1,179	8,184	2,641
Turin	890,529	2,282,197	130.01	6,827	6,850	334
Palermo	674,435	1,271,406	160.59	5,009	4,200	254
Bari	326,344	1,263,820	117.39	3,863	2,780	327
Catania	314,555	1,115,535	182.9	3,574	1,720	312
Florence	382,808	1,013,348	102.32	3,514	3,741	288
Bologna	386,663	1,005,831	140.86	3,702	2,745	272
Genoa	586,655	854,099	240.29	1,834	2,441	466
Reggio Calabria	183,035	555,836	239.04	3,210	766	173
Total	**8,929,680**	**20,024,953**	**2,901**	**39,651**	**3,078**	**505**

Table 4
Motorization rate, vehicular density and traffic index of the metropolitan capitals.
(Sources: ISTAT; TomTom)

City	Motorization rate (no. veh./1000 in..) 2014	Vehicular density (no. veh./km^2) 2014	Traffic index* (%) 2014
Naples	538.2	6,003.0	29
Turin	615.5	5,345.5	22
Milan	515.8	5,123.7	30
Palermo	561.6	3,374.6	42
Florence	510.3	2,833.2	21
Bologna	511.0	1,957.0	22
Bari	538.4	1,932.2	24
Genoa	457.6	1,849.7	22
Rome	619.5	1,843.2	38
Catania	671.1	1,672.8	27
Reggio Calabria	603.6	606.6	32

*Increase in overall travel times when compared to a free flow (uncongested) situation.

Table 5
Road network, road network density and railway network supply index of metropolitan areas.
(Sources: Istituto Guglielmo Tagliacarne; ISTAT; Automobil Club Italia)

City	Highways and primary roads km 2011	Other roads km 2011	Road network density km/km^2.* 100 2011	Railway network supply index* (Italy = 100) 2012
Naples	247	696	79.98	84.84
Genoa	285	1,037	72.08	117.02
Milan	265	804	67.83	152.44
Rome	492	2,379	53.53	109.89
Catania	584	1,327	53.47	44.61
Palermo	925	1,700	52.41	255.86
Reggio Calabria	320	1,358	52.27	150.99
Bari	329	1,565	49.03	64.46
Turin	458	2,766	47.22	311.98
Florence	227	1,410	46.59	132.10
Bologna	325	1,150	39.84	95.83

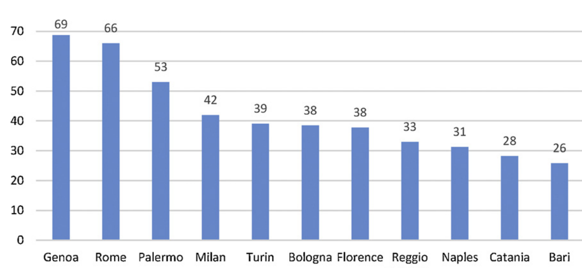

Fig. 2. Capital city population share compared to the whole metropolitan area.

(minimum for Genoa with 457 veh./1000 in. and maximum for Rome with 619 veh./ 1000 in..).

As regards vehicular density, the first four cities (Naples, Turin, Milan and Palermo) show a very high value that has a correlate in the Traffic Index rate. This correlation demonstrates that the large presence of cars in major urban centers, which attract significant daily user flows, results in congestion on the road network, thereby increasing travel times. For instance, in Naples the dominant role of the capital city compared to the surrounding area results in an exponential growth of road trips that is supported by a poor highway network compared to other cities (247 km, Table 5). Together with the morphology of a consolidated urban fabric, the above state cannot support such flows and thus creates serious disbenefits in terms of traffic and pollution. On analyzing the data both for the road network length and the related road network density (the ratio of the length of the road network to the metropolitan area) (Table 5), different situations are shown. Naples, Genoa and Milan show a very high road network density, which appears to be linked rather to the small urban area concerned than the extent of the network. Indeed, with about 950 km of road network length Naples is the city with the lowest endowment (about 5% of the road network of all cities) vs. Turin which represents 15% of the overall Italian network with its 3200 km.

In addition, Turin, Rome (2871 km) and Palermo (2625 km) have the most extensive road network, albeit with a different composition of road types. Palermo has an extensive network of primary roads, but a poor supply of highways, in contrast to the other two cities. Fig. 3, which summarizes the infrastructure network status, highlights the differences in terms of network length and morphology.

Milan, Turin, Bologna and Rome show a clear radio-centric pattern where all roads are drawn from the center through a mesh, showing few cross-links between the axes. The complex and variegated network of the metropolitan area of Naples is also evident.With regard to the rail network, the lack of data for all the metropolitan cities does not allow the study to compare them. The Railway Network Supply Index (defined by the Tagliacarne Institute within the Competitiveness Atlas) should be used with caution since it contains both quantitative and qualitative evaluations of the length of the network and its technical characteristics. Referring to this index, Turin is the city with the best performing rail system, which is in line with the public strategies that have invested significant resources to improve this transportation mode since 1999.

The rail network supply currently comprises eight lines with over 350 trains connecting 93 stations every day, located in several metropolitan municipalities. Bologna and Milan are also equipped with an efficient metropolitan rail system that supports commuting flows gravitate to the cities throughout the day.

4. Results and discussion: interpretation of smart mobility in some italian cities

The aim of this section is to illustrate the results of the research and is divided into two parts. In the first part, the description of the main types of initiatives recorded in the 11 cities is followed by their classification, according to the three main Smart Mobility aspects, namely accessibility, sustainability and ICT. This structure allows us to define an overall taxonomy of the cities in relation both to actions and strategies adopted to improve the efficiency and sustainability of the transport sector. In the second part, through a set of 28 urban mobility parameters, a framework of the 11 cities in 2014 is provided, in order to bring out contradictions or synergies with the interventions that have been implemented.

4.1. How do the Italian metropolitan cities implement smart mobility?

For each city, a database of initiatives was drawn up, being classified in relation both to the promoters who implement them and their typology. In detail, the initiative promoters were classified into the following four categories; universities and research institutes, local authorities and institutions, companies and associations. The initiative typologies can be articulated as follows:

- Research, carried out by universities, research centers, etc. located in the city;
- Interventions that involve the "physical" transformation of the structure or infrastructure concerned, with an advanced stage of implementation or already completed;
- Projects, both intangible and non-initiated interventions; technologies, products and innovations tested or developed in the studied

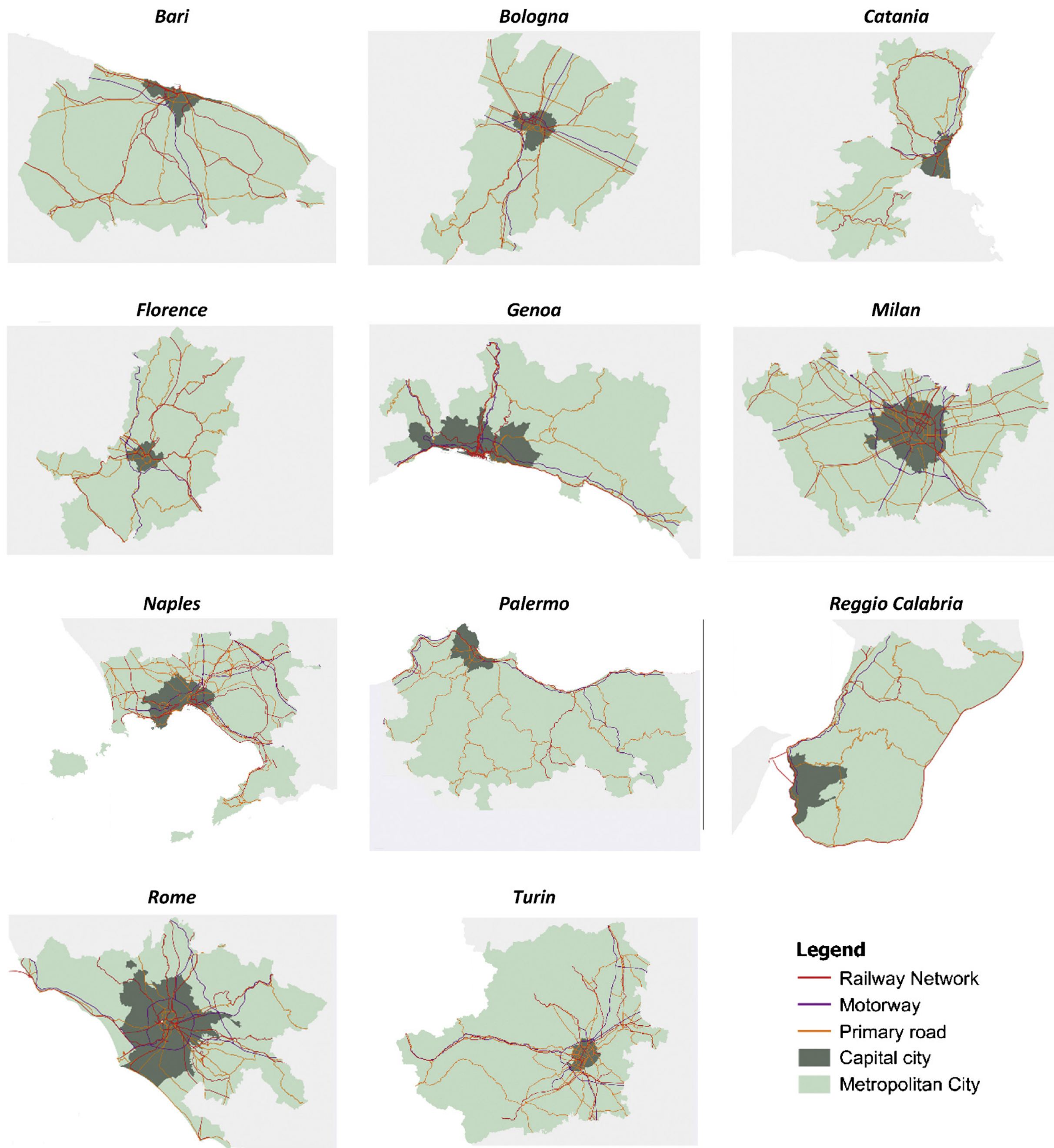

Fig. 3. Road and rail network of metropolitan cities.

city and which include control and monitoring tools, open sensor networks, open data portals, wi-fi networks, apps, etc;

- Plans and programs specifically aimed at adopting the Smart City paradigm; initiatives promoting and disseminating the Smart City approach to a wide audience (info-points, exhibitions, conferences, university and training courses, etc.).

The initiatives under study refer to the period 2010 - 2015. In particular, in relation to the aim of this research, the initiatives were selected taking into consideration those that contribute to the adoption of a smart approach in the Italian metropolitan cities, as well as those that are explicitly related to the use of ICT.

In order to clarify some initiatives, interviews with the stakeholders involved were carried out. The interviews were useful to ascertain to what extent initiatives implemented in metropolitan cities can contribute to developing their Smart Mobility and whether they are part of a general framework and/or a wider decisional process focusing on the implementation of the Smart City. Furthermore, by means of these interviews, initiative content, implementation modes, results and potential replicability were investigated.

The distribution of the 183 initiatives in the 11 cities is shown in Fig. 4. Florence, Milan and Rome are the cities that have invested most in Smart Mobility, with 50% of all initiatives. Overall, Northern Italy cities have developed more initiatives than those in the South and among the latter Palermo seems to be the most receptive to the theme of Smart Mobility, according to its 15 initiatives developed.

As regards the types of initiatives (Fig. 5), about 60% comprise projects and technologies / products (apps, platforms, portals, etc.), while only 2% entail "interventions". These results suggest that a mature stage of applying innovations to the mobility sector is still far off.

Local authorities are by far the main actors in the process of implementing the Smart Mobility approach (Fig. 6): the Municipalities

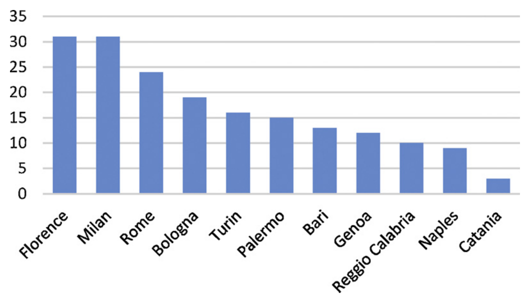

Fig. 4. Smart Mobility initiatives in the Italian metropolitan cities.

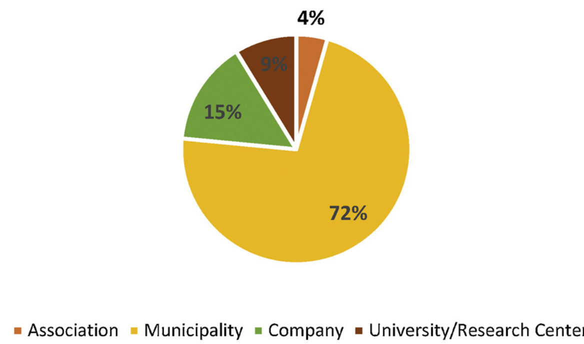

Fig. 6. Smart Mobility initiatives by promoter.

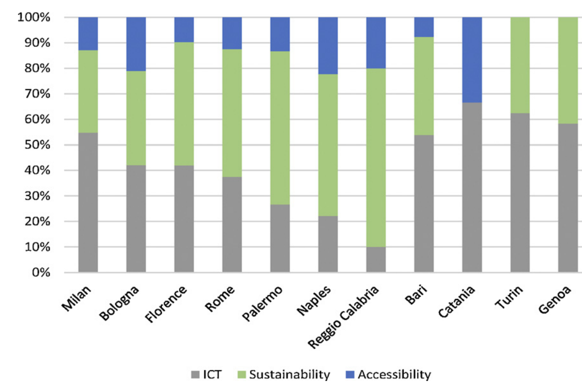

Fig. 7. Percentage distribution of initiatives related to ICT, Sustainability and Accessibility.

have implemented more than 70% of the initiatives, even though in the Northern cities there is a greater presence of companies in this sector compared to other cities elsewhere. Although the classification of the initiatives into the three categories identified (Fig. 7) may be partially conditioned by the specific "cut" adopted for the selection of the initiatives, the results allow us to obtain interesting insights into how the Italian cities are tackling the challenge of smart and sustainable mobility.

Regarding accessibility, some cities (namely Milan, Naples, Turin and Rome) have been focusing on strengthening public transport through expensive infrastructural solutions, such as the construction of new urban rail lines. Other ongoing projects are related to parking lots (not only for interchange), the modernization of the traffic light network or the improvement of local public transport supply by low environmental impact transport modes (i.e. trams in Florence and trolleybuses in Milan and Bologna).

The 11 metropolitan capitals have developed the same number of actions related to sustainability and ICT, albeit interpreting these aspects in different ways: some cities have implemented more sustainability initiatives through the promotion of cycling mobility (i.e. Milan, Genoa and Turin), the introduction of congestion charge zones (Milan) and mobility sharing as a suitable alternative to private car use (i.e. Milan and Turin). In other cases, ICT is playing a predominant role, probably due to the interests of manufacturing companies. For instance, Milan has adopted a considerable number of technologies and services both to provide users with information and to manage traffic and transport logistics.

Table 6 gives a synopsis of the kind of initiatives the Metropolitan cities are implementing and three main clusters may be distinguished: the first includes Milan, Florence, Rome and Bologna; the second, Turin, Genoa and Bari; the last, Naples, Palermo, Reggio Calabria and Catania. The cities in the first cluster are investing the most in developing Smart Mobility, given that they have recorded the highest number of initiatives among the selected cities and present most of the

Table 6
Distribution of initiatives by type of Smart Mobility action.

City	Accessibility			Sustainability			ICT			
	A	B	D	C	F	G	E	H	J	K
Milan	•	•	•	•	•	•	•	•	•	•
Florence	•	•		•	•	•	•	•	•	•
Rome	•	•		•	•	•	•		•	•
Bologna	•	•		•	•	•	•	•	•	•
Turin				•	•	•	•		•	
Genoa				•	•	•	•	•	•	•
Bari	•			•		•	•		•	•
Naples	•			•	•	•		•		•
Palermo	•			•	•	•			•	•
Reggio Calabria		•	•	•	•			•		
Catania		•							•	•

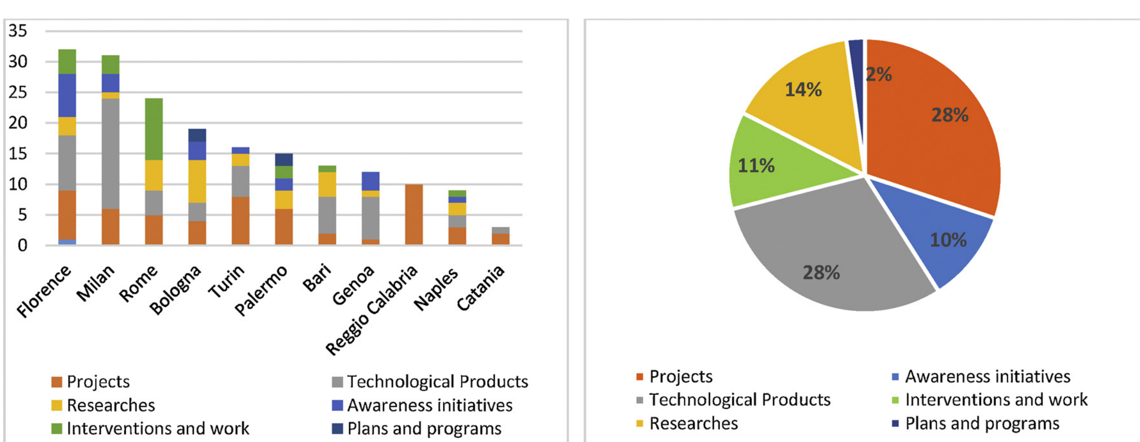

Fig. 5. Smart Mobility initiatives by city and type.

types of actions implemented. Milan is the city that overall has developed numerous smart and sustainable mobility initiatives such as enhancing bike, car and scooter sharing and electric vehicles, introducing ticketing and mobile device payment and improving consumer information with electronic stop signs. Furthermore, EU-funded pilot projects have recently been implemented to improve last mile freight transport so as to reduce congestion and polluting emissions (URBeLOG, OPTI-LOG and FR-EVUE projects) (Pinto, 2014). Florence, in addition to improving public transport by constructing a new tram line, has also been promoting several cycling mobility projects that are particularly suitable for a city with high traffic flows. High traffic congestion has prompted the administration in Rome to seek solutions based on technology platforms and a portal that is able to provide real-time traffic information and improve daily trips in the city. Similar to Florence, Bologna has promoted initiatives to enhance public transport and especially their inter-modality, and support soft mobility modes, such as the spread of apps to give useful information to users about their trips in the city.

The cities in the second cluster are not implementing initiatives for all the identified Smart Mobility categories, except for Bari which is the only southern Italian city in the cluster. The analysis of its initiatives reveals that, as with cities in the North, it has been investing mainly in promoting sustainable forms of mobility and creating innovative and supportive mobility platforms. As regards Turin, the city has implemented initiatives not only to guarantee better diffusion of soft modes of mobility, but also to make the current mobility system of the city more efficient through the use of ICTs and the realization of an ITS for urban traffic management. In contrast, in Genoa the use of ICTs is mainly linked to mobility platforms and apps for users in order to promote the use of shared forms of transportation. The last cluster contains four southern Italian cities that are implementing actions to make urban mobility more sustainable. Moreover, Palermo, which has been implementing several initiatives for all types of Smart Mobility action, is also investing in creating web platforms to promote forms of mobility sharing.

Finally, one last consideration on the lack of the geographical balance in the distribution of the initiatives. About 73% of actions are concentrated in northern and central metropolitan cities, while in their southern counterparts the interventions are sporadic and represent pilot projects rather than broad-scale actions. Moreover, such few initiatives are mainly related to accessibility rather than sustainability or ICT and this highlights the persistent infrastructure gap characterizing Italy. Fig. 8 shows that the metropolitan cities in central Italy have a balanced distribution of the three Smart Mobility categories, while those in the North, which have achieved a good level of transport efficiency, aim more at ICT spread.

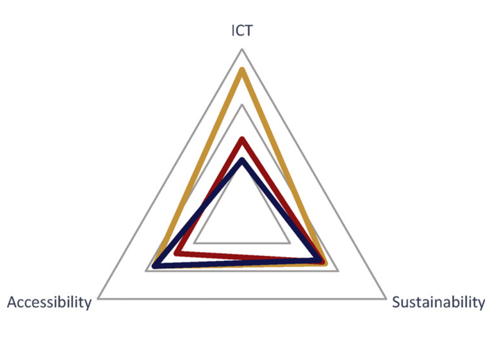

Fig. 8. Performance in the three categories by geographical area (%).

4.2. *Is the mobility of metropolitan Italian cities really accessible, sustainable and technologically advanced?*

After analyzing the framework of Smart Mobility initiatives, the use of parameters and synthetic indicators (step 4 of the methodology) allowed us to audit the status of Italian Smart Mobility.

With regard to accessibility and the single parameters (i.e. local PT supply and demand, availability of parking lots) (Fig. 9) there is a significant gap between cities in the North and South. The latter have below-average parameter values, with the exception of Naples regarding the rail network and bus stop density data (slightly above average also for Bari). Milan and Turin achieved the best performance and, especially with regard to the local PT supply, have far higher values than average. The cities in central Italy record higher average values except for local PT lines.

Moving on to sustainability (Fig. 10), the results are similar to those found for the accessibility category, with the exceptions of Milan and Genoa. The performance of these two cities is weaker. In particular, Milan performs poorly with respect to ecological buses and ecological cars, while Genoa shows below-average values for all parameters, with the exception of the two car-sharing parameters. Finally, some cities have a large number of pedestrian zones and restricted access zones (first of all, Florence and Milan due to traffic restrictions for the entire historic center, as well as Naples and Palermo). As regards the accessibility and sustainability indicators (Fig. 11) Milan, Turin, Florence and Bologna have above-average values, while all the other cities deviate from the mean value, obviously with different ranges.

The comparison between the Smart Mobility indicators and the framework of the initiatives described above allows us to assume that the Italy's metropolitan cities are not developing transport policies with view to improving urban mobility smartness. For instance, although cities in the South perform poorly, local decision makers seem to pay no particular attention to implementing Smart Mobility actions.

Cities that are investing most in sustainability, ICT and accessibility are those that already have the best performance, confirming the key role of an efficient transport supply in the most advanced urban systems. Nevertheless, some critical issues emerge even for the “smartest” cities. For instance, Milan seems to invest more in ICT rather than in sustainability issues despite its air pollution levels; Genoa has also triggered sporadic initiatives in the sustainability category, perhaps because of the particular morphological configuration of its territory.

If one considers mean accessibility and sustainability indicators, the result is a new indicator that confirms almost all the framework described above (Fig. 12). In general, northern and central cities are the most sustainable and accessible in terms of urban mobility, except for Genoa and Rome.

With regard to cities in the South, the new index shows some differences in accessibility and sustainability indicators. In particular, it highlights that Bari and Palermo have, in general, lower levels of urban mobility than those shown for each indicator, mainly because of the negative performance in accessibility.

5. Conclusions

This study gave an overview of how Italy's metropolitan cities are implementing the Smart Mobility model to promote more sustainable and efficient mobility. Smart Mobility was organized into three categories, namely accessibility, sustainability and ICT. The categories were used to classify initiatives in the transportation sector found in each city. A set of 28 parameters were then employed to identify contexts with the best performance in terms of accessibility and sustainability. Finally, from the comparison between initiatives and performance measured by the indicators, there emerged strengths and weaknesses in the Smart Mobility system, the result of policies implemented by local decision-makers.

Our results constitute useful food for thought for administrative and

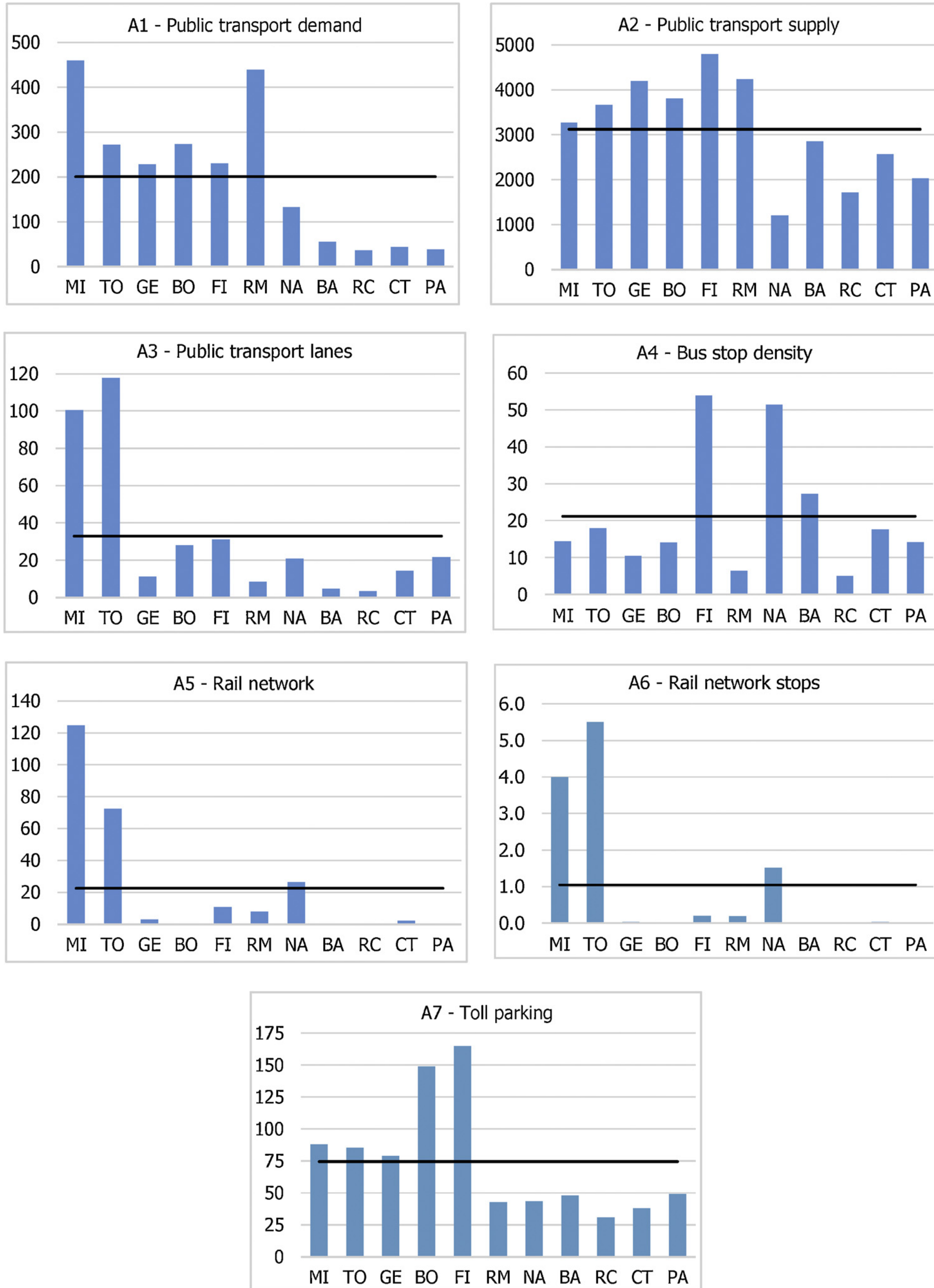

Fig. 9. Accessibility parameters.

technical staff in local authorities engaged in implementing policies to develop Smart - and sustainable - Urban Mobility and in choosing effective strategies for ensuring the success of initiatives taken at the metropolitan level. In this regard, the analysis conducted as part of this study may represent a useful point of reference in methodological terms for evaluating the effectiveness of possible intervention strategies to develop the Smart Mobility system, since it would allow such strategies to be defined and implemented within an appropriately detailed framework of knowledge regarding the urban context.

Indeed, the analysis of demographic and infrastructural features (see Section 3) showed that the most populous cities (i.e. Milan and Rome) and those in the South (especially, Palermo and Reggio Calabria) would most need to invest in a sustainable mobility model in order to reduce negative impacts – such as congestion and pollution – caused especially by private vehicular traffic and improve quality of life in those urban areas (Gargiulo & Tremiterra, 2016).

As amply shown by our study, Smart Mobility is an opportunity for cities to enhance their performance levels of the mobility system. Nevertheless, there is a significant gap among the Italian cities analyzed, especially in relation to different geographical areas. The cities in the North are endowed with efficient, sustainable transport systems and have reached a mature stage of ICT application, albeit still far from the standards of some other European cities (for instance, Amsterdam according to http://www.smart-cities.eu). Although in some cases the initiatives are driven by interests of important business groups (e.g. Milan) and in others by EU funding (e.g. Genoa), the northern Italian cities recorded a number of actions and indicator values above the average of the other cities considered. In the southern cities, indicators recorded below-average values and the share of initiatives was also lower than in the other cities analyzed. Furthermore, such initiatives

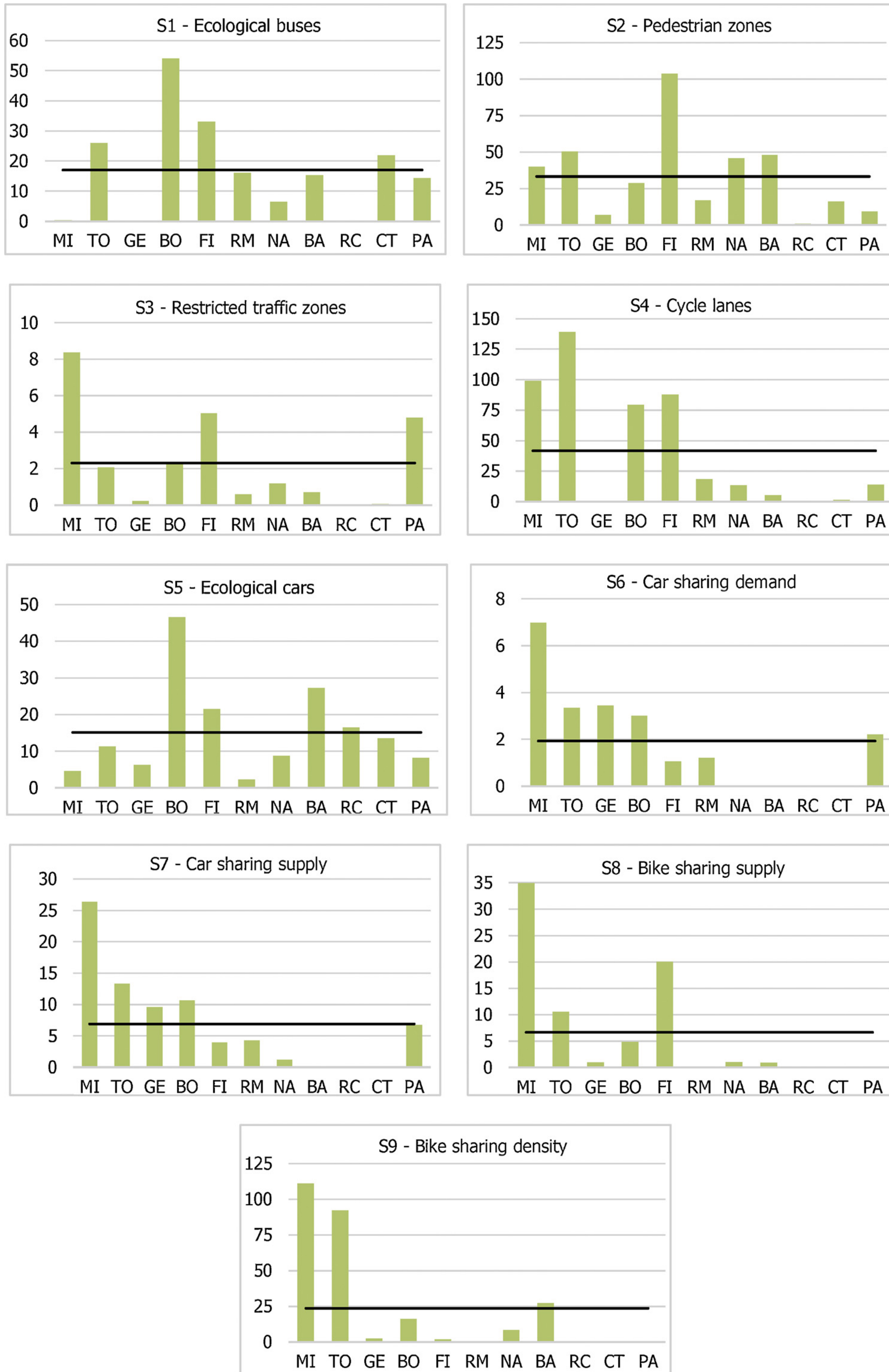

Fig. 10. Sustainability parameters.

were found to be sporadic events and were not integrated into a policy framework aimed at increasing sustainable mobility.

For instance, why promote soft mobility initiatives if the related infrastructure networks are not available and there are low road safety levels? Moreover, in southern Italian cities many interventions were developed as European pilot projects, and it is not still clear whether and how they can be "scaled up" to Metropolitan areas. At the same time, the use of ICTs can be useful and effective in cities with an efficient transport system, while it can be a catchy label if blindly "placed in" a "backward" context (Battarra, Gargiulo, Pappalardo, Boiano, & Oliva, 2016). Consequently, given the new institution of metropolitan cities under Law 56/2014, the topic of how ICT in mobility sector can support cities in dealing with the tasks assigned to them by the same law (e.g. the integrated management of the public transport system) has not yet been sufficiently explored. As highlighted, there is a lack of useful data to measure the ICT category and, consequently, the related indicator, since the available parameters are dichotomous. Hence, in order to have an efficient Smart Mobility Index it would be necessary not only to enrich the parameters referring to accessibility and sustainability, but also have parameters capable of effectively measuring

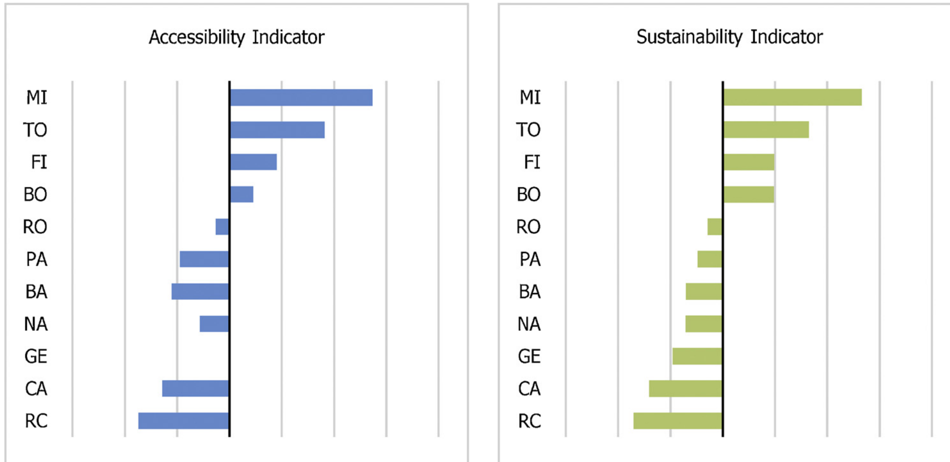

Fig. 11. Accessibility and Sustainability indicators.

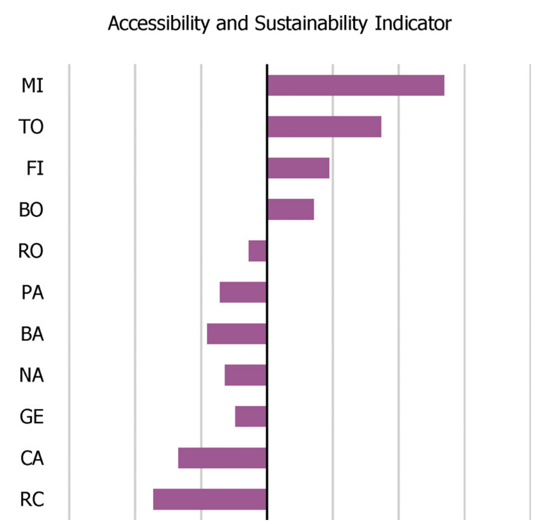

Fig. 12. Accessibility and sustainability indicator.

the relationship between use of ICTs and urban contexts. Moreover, because of the lack of available data for other years (in this study the evaluation of the levels of Smart Mobility referred to one year) in order to verify to what extent the various initiatives that are currently being implemented in the metropolitan cities will have positive and effective impacts on the urban mobility system, a further investigation considering at least two different years would be required. Furthermore, such a lack of data does not allow the Italian metropolitan cities to be compared to their European counterparts. In this perspective it could be useful to evaluate the Italian gap in developing the smart and sustainable mobility sector within the broader European context.

In conclusion, it is evident that the most successful cities have included ICTs in a transport system developed through an integrated and coordinated urban planning system. Indeed, a well-defined vision of the Smart City and the related role of mobility allow for the implementation of initiatives and projects which, beyond the evocative slogan, are able to respond to community needs and effectively support sustainable activities.

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