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Corresponding Author: Dr. Chiara Garau, Ph.D

Corresponding Author's Institution: University of Cagliari

First Author: Chiara Garau, Ph.D

Order of Authors: Chiara Garau, Ph.D; Francesca Masala; Francesco Pinna

Abstract: In recent years, city officials in Cagliari (Italy) have shown a particular interest in policies and strategies that promote sustainable urban mobility. The Urban Mobility Plan (Piano Urbano della Mobilità), drafted in 2009, provides an important tool, transforming Cagliari's mobility in a smart direction, by promoting alternative means of transport to the private vehicle. This paper describes a quantitative methodology for evaluating urban mobility in Cagliari, using a synthetic indicator, and suggests steps that Cagliari could take to meet international best practices for transportation. The data needed to analyse Cagliari's urban mobility are gathered, and the findings are compared to those from other comparable international cities. This intercity comparison allows the authors to consider how best to orient Cagliari's mobility towards international best practices.

Suggested Reviewers: Beniamino Murgante Prof.
Associate Professor, School of Engineering, University of Basilicata
beniamino.murgante@unibas.it

Alessandro Plaisant Prof.
assistant professor , Department of Architecture, Design and Urban Planning, University of Sassari
plaisant@uniss.it

*Cover sheet (only manuscript item that should display author names and affiliations)

Cagliari and smart urban mobility: Analysis and comparison

Chiara GARAU (corresponding author)

Department of Civil and Environmental Engineering and Architecture – DICAAR,

University of Cagliari, Italy.

Via Marengo, 2; Tel: +39 070 675 5565; E-mail: cgarau@unica.it

Francesca MASALA

Department of Civil and Environmental Engineering and Architecture – DICAAR,

University of Cagliari, Italy.

Via Marengo, 2; Tel: +39 070 675 5256; E-mail: fmasala@outlook.it

Francesco PINNA

Department of Civil and Environmental Engineering and Architecture – DICAAR,

University of Cagliari, Italy.

Via Marengo, 2; Tel: +39 070 675 5256; E-mail: fpinna@unica.it

*covering_letter

[20th August 2015]

Dr. A. Modarres
Editor-in-Chief
Cities: The International Journal of Urban Policy and Planning

Dear Dr. Modarres,

I, along with my coauthors (Francesca Masala and Francesco Pinna), would like to ask you to consider the attached manuscript entitled **Cagliari and Smart Urban Mobility: Analysis and Comparison** for publication in *Cities: The International Journal of Urban Policy and Planning* as a full-length article.

This study analysed the smart urban mobility of the city of Cagliari, Sardinia relative to other international cities, by conducting an intercity comparison of six key mobility variables: public transport, cycle lanes, bike sharing, car sharing, private mobility support systems, and public transport support systems. Based on the study's findings, the authors make six recommendations to improve Caglari's smart urban mobility capabilities.

Smart urban mobility is a key component of urban policy in the twenty-first century. To satisfy their citizens' transport demands, city managers must be able to evaluate the strengths and weaknesses of their current urban transport capabilities, and implement informed proactive measures to enhance these capabilities. This paper describes a system of quantitative indicators that can be used to assess the viability of smart mobility in terms of public transport, alternative mobility options, and technological mobility services. We believe that the findings of this study are relevant to the scope of your journal and will be of interest to its readership.

Please consider, as potential referees, Beniamino Murgante, and Alessandro Plaisant.

Some parts of this manuscript were presented in its early first version at the 15th International Conference on Computational Science and Its Applications (ICCSA 2015 http://www.iccsa.org/), and in this conference we won the best paper award. We certify that the submission is original work and is not under review at any other journal.
All study participants provided informed consent, and the study design was approved by the appropriate ethics review boards. All the authors have approved the manuscript and agree with submission to your esteemed journal. There are no conflicts of interest to declare.

Thank you for your consideration. I look forward to hearing from you.

Sincerely,

Chiara Garau
University of Cagliari (Sardinia - Italy)
DICAAR - Department of Civil and Environmental Engineering and Architecture
Via Santa Croce, 67 - Cagliari, 09124 - Italy
tel. (+39) 070.6755371
Email: cgarau@unica.it

Cagliari and smart urban mobility: Analysis and comparison

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This paper is the result of the joint work of the authors. In particular, ‘Cagliari and smart urban mobility’ has been jointly written by the authors. Chiara Garau has written the 'Introduction', ‘Applying the methodology in Cagliari’, 'Results comparing Cagliari to others urban contexts' and subparagraphs. Francesco Pinna has written the ‘Methodology’ with subparagraphs, the 'Discussion' and the ‘Conclusions’, and Francesca Masala has written ‘Cagliari: City features and mobility’. This study is supported by the MIUR (Ministry of Education, Universities and Research [Italy]) through a project entitled *Governing tHe smart city: a gOvernance-centred approach to SmarT urbanism - GHOST* (Project code:RBSI14FDPF; CUP Code: F22I15000070008) financed with the SIR (Scientific Independence of young Researchers) programme. We authorize the MIUR to reproduce and distribute reprints for Governmental purposes notwithstanding any copyright notation thereon. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the MIUR.

***Response to Reviewers**

We would like to thank you for spending time reviewing our paper. We appreciate your valuable comments and suggestions.

Reviewers' comments:

Reviewer #1:

The adaptations made in the paper evidence the efforts of the authors to take all remarks and advice of the reviewers into account, which significantly improved the paper. Two small observations are to be added. First, in the paper there is no consistency with regards to the language: both American and British English are implemented.

We improved the reading of our paper with the English revision of the work made by English native speakers

Second, in the paper it is claimed that electric cars are fully sustainable. Although the benefits of an electric fleet are fully acknowledged, it is advised to nuance this statement.
We changed as suggested

Reviewer #2:

The author has considered all my suggestions in the revised version. After this improvement the paper "Cagliari and smart urban mobility: analysis and comparison" can be accepted for the publication.

Thank you!

Cagliari and smart urban mobility: analysis and comparison

Research Highlights

This paper summarises an intercity comparison of smart urban mobility.

We analyse the smart urban mobility of Cagliari, Italy.

Mobility variables are public/private transport, cycle lanes, and bike/car sharing.

We use a quantitative methodology to assess smart urban mobility.

Cagliari and smart urban mobility: ~~analysis~~ Analysis and comparison

Abstract

In recent years, city officials in Cagliari (Italy) have shown a particular interest in policies and strategies that promote sustainable urban mobility. The Urban Mobility Plan (*Piano Urbano della Mobilità*), drafted in 2009, provides an important tool, transforming Cagliari's mobility in a smart direction~~,~~ by promoting alternative means of transport to the private vehicle. This paper describes a quantitative methodology for evaluating urban mobility in Cagliari, using a synthetic indicator, and suggests steps that Cagliari could take to meet international best practices for transportation. The data needed to analyse Cagliari's urban mobility are gathered, and the findings are compared to those from other comparable international cities. This intercity comparison allows the authors to consider how best to orient Cagliari's mobility towards international best practices.

Introduction

Continuing population growth and uncontrolled urbanization have led to the development of a new model of the city, called a 'smart city'. In recent years, the definition of a smart city has been widely discussed, leading the European community, academics, and public and private companies to develop a strong interest in this topic. However, there is as yet no unique definition of this concept. In this paper, the authors interpret this term as a synonym for growth, environmental sustainability, and inclusiveness. In all of this, the Information Communication Technology (ICT)'s tools enable ~~smart cities'~~ leaders of smart cities to foster urban development (Caragliu ~~and~~ & Bo, 2015), to 'economize time, improve individual mobility, facilitate access to information and services, save energy and resources, and participate in urban decision-making processes' (Kunzmann, 2014, p. 12). In doing so, a holistic and integrated approach is adopted to all aspects of development.

This integrated approach is also reflected in the transport sector—an important component of the economic and social development of urban areas.

The principal role of transport in economic growth depends on the capacity to move people and things, and on the application of intelligent transport management processes that improve the quality of life (WBCSD, 2004; Montanari, ~~Gragnani, & Franceschini~~et al., 2008; European Commission, 2011).

Chun and Lee (2015) write that smart mobility 'is a concept of comprehensive and smarter future traffic service in combination with smart technology. A smart mobility society is realized by means of the current intelligent traffic systems'. Moving smartly depends on an efficient means of public transport ~~that~~ ha~~s~~ving a low environmental impact ~~—~~(reduced greenhouse gas emissions and energy consumption), ~~—~~a network of safe and continuous cycle lanes, and interchange parking that avoids the city congestion, among others~~etc~~. However, the authors believe that the mobility cannot be considered smart if it is not also sustainable.

Transferring part of the demand from the private car to public transport influences the smartness of the urban context under study. However, the overall level of smartness ~~desidered~~ is also affected by the transport system used. For example, this transfer of demand could occur with the use of internal combustion means, rather than electrical means. In the latter case, the level of smartness is greater than in the first, because it is more sustainable. Furthermore, the smart mobility concept appears to be more dynamic than the sustainable mobility concept, because it depends on the technology used. In the above example, the transfer of existing demand could occur, regardless of its sustainability. For example, reducing private car traffic appears smart. As a second step, the means could simply be replaced with electric cars even if the demand is unchanged. This positively impacts the level of smartness because electric cars are more

sustainable. In fact, it is generally accepted that 'sustainable transport implies finding a proper balance between current and future environmental, social, and economic qualities', and that 'sustainable transport is that which satisfies current transport needs without jeopardising the ability of future generations to meet these needs' (Yigitcanlar, et al., 2008; p. 29).

This complexity is also attracting interest, especially with regard to smart cities' strategic policies (Sheller & Urry, 2006; Banister, 2008; Bertolini, 2012; Lopez-Lambas, et al., 2013; Papa & Lauwers, 2015).

A major difficulty of addressing congestion in urban areas—greenhouse gas emissions and the integration of various planning tools—is related to the lack of clear definitions of sustainability and sustainable transport (van Nunen et al., 2011).

City planners often tend to focus on sustainable transport objectives and on measurable impacts, ignoring more complex immeasurable impacts (such as policies and human behaviours), that might play a greater role. According to Litman and Burwell (2006;, p. 333), 'sustainable decision making can therefore be described as planning that considers goals and impacts regardless of how difficult they are to measure'. Bertolini (2012) analyses the evolutionary processes of cities from the time of the industrial revolution to the modern city, and focuses on how mobility has evolved in relation to urban changes, and especially to those changes linked to contemporary societies' needs. These needs become problematic if increasingly faster means of transport include more secure, integrated, and, above all, sustainable, transport. 'Planning urban mobility in the contemporary world must start from the acknowledgment of this core dilemma, and develop conceptual and practical tools for coping with it' (Bertolini, 2012;, p. 18). Papa and Lauwers (2015) note that the smart mobility concept evolved in two stages. In the first stage, technology was a tool used to improve and optimise transport planning. The second stage incorporated the consumer as a key component of smart mobility.

This analysis suggests that viable mobility achieves an effective and efficient transport system through the use of technology (Ali-Vehmas & Casey, 2015; Ilarri et al., Stojanovic, & Ray, 2015), and the integration of physical and technological capital with human and social needs (Caragliu et al., de Bo, & Njkamp, 2011; Garau, 2015). Other researchers have concluded that contemporary sustainable transport mobility strategies must propose and promote alternative modes of travel, such as e-mobility (Arena et al., 2013; John et al., 2013; Longo & Roscia, 2014), and the closer integration of transport planning with the territory (Hull, 2011; Jones, 2012; Lopez-Lambas et al., 2013; Bos et al., Straatemeier, & Temme, 2014; Kim et al., Hwang, & Suh, 2014; Manaugh et al., Badami, & El-Geneidy, 2015).

Although performing this kind of integration is complex, Mattoni et al. , Gugliermetti, and Bisegna (2015) propose a method for advancing integrated planning that is useful for local administrators, by analysing the interrelationships

between the various strategic axes of smart cities (economy, mobility, environment, people, living, governance), in order to create a global vision of what happens in urban settlements.

The EU strategies ‘~~'~~Horizon ~~2020'~~ 2020’ set targets for urban contexts (such as: transforming the use of conventionally fuelled vehicles in urban areas, tackling urban road congestion, demonstrating and testing innovative solutions for cleaner and better urban mobility), and consequently, cities in the EU now use benchmarking to monitor and evaluate their implementation of smartness~~,~~ and the effectiveness of their transportation strategies (Giffinger et al., 2007; Zhu, 2009).

Giffinger et al.~~, Haindlmaier, and Kramar~~ (2010~~,~~ , p. 300) assert that ‘city rankings have become an important empirical base for disclosing comparative advantages and sharpening specific profiles and consequently for defining goals and strategies for future development’. However, this type of assessment has drawbacks~~,~~ if cities fail to collaborate in the collection and dissemination of their data for a major comparative study, and/or when they delay improving their performance, after obtaining a good ranking. Thus, they lack the dynamic characteristic typical of being smart. Positive results should not be considered a goal~~,~~ but an incentive to continuously improve.

Few studies measure smartness using quantitative indicators (Moeinaddini et al.~~, Asadi Shekari, & Zaly Shah~~, 2014; Garau et al.~~, Masala, & Pinna~~, 2015)~~,~~ because of difficulties associated with finding the necessary data, and the lack of a well-defined system of indicators. Castillo and Pitfield (2010~~,~~ p. 181) note that selecting qualitative indicators—applicable independent of the availability of data—is problematic, because there are many possible potential indicators, and identifying those most representative of system performance is challenging.

The innovative dimension of this paper is that it describes a system of quantitative indicators that can be used to assess smart mobility in terms of public transport, alternative mobility options, and technological mobility services. The authors chose to deepen these aspects, because they consider these factors to be principal aspects of smart mobility. In particular, public transport and alternative mobility options are fields of action, while technological mobility services enhance the efficiency and effectiveness of the fields of action.

Cagliari has been chosen as the case study~~,~~ because officials in this city have for three years been engaged in a smart mobility urban development project. They are encouraging the use of public transport, and experimenting with alternative forms of mobility. Comparing~~son~~ Cagliari to other national and international cities (to allow subsequent generalisations) facilitates the evaluation of today’s development policies in relation to mobility, and provides an orientation to mobility in Cagliari. Details of the methodology used for this case study are explained next, after which a city profile of Cagliari ~~is provided,~~ and a description of the city’s mobility characteristics are provided. Application of the study’s methodology to Cagliari is explained, and the results are compared to other urban contexts. The discussion

summarises the study's findings, and the concluding section provides six recommendations for improving Cagliari's mobility.

1 Methodology

Numerous studies have used indicators to measure and evaluate the performance of various sectors, including mobility (Giffinger et al., 2007; Caragliu et al.~~, de Bo, & Njkamp~~, 2011; Debnath et al. ~~, Chi, Haque, and Yuen~~ (2014) analyse private and public mobility, as well as commercial and emergency mobility. Four membership categories have been identified for each selected indicator: non-availability, testing, partial coverage, and full coverage. Different subsets of indicators have been identified to analyse these aspects of mobility. Moeinaddini et al. ~~, Asadi-Shekari, and Zaly Shah~~ (2014) use indicators extrapolated from the international organisation for public transport authorities, operators, and policy decision-makers (UITP) to evaluate private motorized mobility in Hong Kong and Chicago. This evaluation uses a mobility index 'for evaluating transportation in cities at the macro-level' (Moeinaddini et al., 2014~~;~~, p. 30). Garau et al. ~~, Masala, and Pinna~~ (2015) construct a synthetic urban mobility indicator to assess the infrastructures of different transport services (public transport, cycle lines, bikes, and car sharing, and the technological tools available to support mobility), and to assess the mobility options' smartness.

1.1 Determining the synthetic indicator

Garau et al. ~~, Masala, and Pinna~~ (2015)~~,~~—to whom we particularly refer in this paragraph—chose six variables to generate a smart mobility synthetic indicator. In comparison, the value of this paper is demonstrating the applicability of the methodology previously applied to Italian case studies for international cities, despite cultural, behavioural, and legislative differences. This article also facilitates understanding the variables used, and highlights the relative ranking of each city using a graphical representation of the key variables: public transport, cycle lanes, bike sharing, and car sharing.

This synthetic indicator is considered smart because it combines the main modes of transport with smart ~~technology's~~ technology's management of movements. It can be used to analyse a city's mobility from different aspects, since each variable is comprised of a sub-set of the indicators shown in Table 1.

Table 1. Variables and indicators used to evaluate smart mobility (Garau et al., 2015~~;~~ , p. 615).

Variables	*Indicators*	*Sub-Indicators*		*Unit*
Public transport	I_{PT}	I_{BND}	Bus network density	km/100 km^2
		I_{DPT}	Demand for public transport	passengers per year/inhabitants
Cycle lanes	I_{CL}	I_{CLD}	Cycle lanes density	km/100 km^2
		I_{CLI}	Cycle lanes for ten thousand inhabitants	km/10.000 inhabitants
Bike sharing	I_{BS}	I_{BSD}	Bicycle station density	n°/km^2
		I_{BPI}	Bicycle per thousand inhabitants	n°/1.000 inhabitants
Car sharing	I_{CS}	I_{CI}	Car for ten thousand inhabitants	n°/10.000 inhabitants
		I_{SI}	Station for ten thousand inhabitants	n°/10.000 inhabitants
Private mobility support system	I_{PMSS}	I_{VMS}	Variable message sign	yes=1,00; no=0,00
		I_{STA}	SMS service for traffic alerts	yes=1,00; no=0,00
		I_{EPPS}	Electronic payment park systems	yes=1,00; no=0,00
		I_{AMD}	Applications for mobile devices	yes=1,00; no=0,00
Public transport support system	I_{PTSS}	I_{EBSS}	Electronic bus stop signs	yes=1,00; no=0,00
		I_{ETPS}	Electronic ticket payment system	yes=1,00; no=0,00
		I_{RSWT}	Information on routes, schedules and waiting times	yes=1,00; no=0,00
		I_{TPC}	Travel planner for the route calculation	yes=1,00; no=0,00
		I_{TTO}	Travel tickets online	yes=1,00; no=0,00

The first four variables in Table 1 are measurable indicators (identified by one or more units of measurement), while the last two indicators are evaluated for their presence or absence with a numerical value. The synthetic indicator of smart mobility has been defined with a geometric mean, thereby allowing researchers to merge the six variables under study, using Formula 1:

$$I_{SM} = (I_{PT} * I_{CL} * I_{BS} * I_{CS} * I_{PMSS} * I_{PTSS})^{\wedge (1/6)} \quad (1)$$

Standardization enabled the comparison of each variable's indicators, which are expressed in different units, and facilitated the design of a scale that could be used to evaluate our data. We chose a scale in which the minimum value corresponds to 0, 01, and the maximum value is 10. Formula 2, as follows, is used for standardizing sub-indicators:

$$x_{ir} = \{[x - \min(x_i)] / [\max(x_i) - \min(x_i)]\} * 10 \quad (2)$$

where:

x_{ir} = standardised indicator

x = indicator

min (x_i) = minimum value of the indicator

max (x_i) = maximum value of the indicator

Once all the data were standardised, it was possible to aggregate the sub-indicators described in Table 1, using Formula 3 (Mazziotta et al.~~, Pareto, & Vidoli~~, 2008; Garau et al.~~, Masala, and Pinna~~, 2015).

$$x = (x_1 + x_2 + \ldots + x_n)/\, n \tag{3}$$

1.2 Graphical benchmarking of indicators

After determining the synthetic indicator for smart mobility, comparisons of urban areas were performed using a coordinate system to analyse the following individual services: public transport, cycle lanes, bike sharing, and car sharing. In this system, each variable is composed of two indicators (x and y), and it is therefore possible to make a graphical representation of comparisons between the cities.

Abis and Garau (2014~~;~~ , p. 20)~~,~~ write that by analysing each variable individually, 'two punctual numerical values were thus obtained, so as to allow the representation of every spatial variable as a pair of coordinates'.

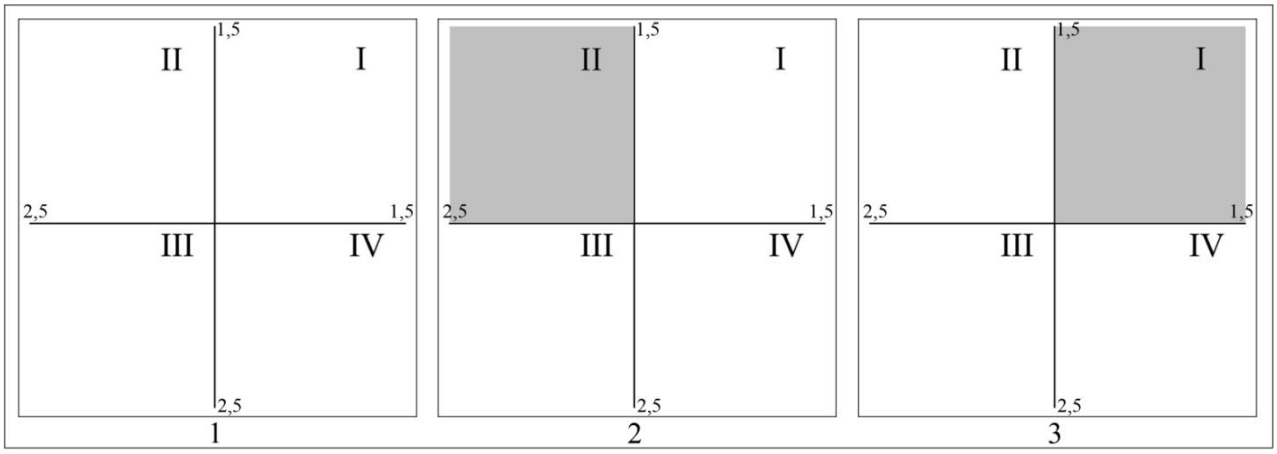

Fig. 1. Schemes representing intercity comparisons using individual variables.

The graph in Figure ~~4~~1.1 is divided into four quadrants, whose axes are obtained from the averages of the cities studied. Quadrants I and II generally represent optimal situations, depending on the variable considered, while quadrants III and IV represent cases with negative situations or situations that are not acceptable. Each variable analysed was assigned a quadrant with an optimal situation.

Regarding the public transport service, the x-axis is identified by the indicator bus network density $XI_{BND(i)}$, and the y-axis is defined by the indicator demand for public transport $YI_{DPT(i)}$. Figure ~~4~~1.2 shows the scheme for this variable, so the cities that fall in quadrant II are those that have an optimal situation. It is preferable to have a smaller, but widely used network, than a huge poorly used infrastructure.

Regarding the cycle lanes, the x-axis is defined by the indicator cycle lanes' density $XI_{CLD(i)}$, while the y-axis is identified by the indicator cycle lanes for ten thousand inhabitants $YI_{CLI(i)}$. Figure ~~4~~1.3 identifies the optimal quadrant for this service as being the first. In fact, if a bicycle lane is developed as a network, in an extended way, and is continuous and safe, its use by cyclists will be greater.

Regarding the bike sharing service, the x-axis is identified by the indicator bicycle station density $XI_{BSD(i)}$, and the Y-axis is defined by the indicator bicycle for one thousand inhabitants $YI_{BPI(i)}$. Also for this variable, the scheme representing the optimal situation is Figure ~~4~~1.3, because having a bike sharing service with good distribution throughout the city supports its use.

Regarding the car sharing service, the x-axis is defined by the indicator car for each ten thousand inhabitants $XI_{CI(i)}$, while the y-axis is identified by the indicator station for each ten thousand inhabitants $YI_{SI(i)}$. Also for this indicator, as for cycle lanes and bike sharing, the optimal situation occurs in the first quadrant. An extensive network of stations in the territory~~,~~ coupled with a good number of vehicles per inhabitant, is ~~are~~ the key feature~~s~~ needed to encourage people to use these services.

To facilitate the reading of graphs, numerical values were expressed in logarithmic units.

2 Cagliari: City features and mobility

Cagliari (Figures 2 and 3) is the capital city of the Sardinian Region, Italy. It is located on the southern coast of the Island of Sardinia, and is considered the ~~island's~~ island's political, economic, tourist, and cultural centre. The city covers an area of 86.05 square kilometres, has a population of 154,019, and a population density of 1,790 people per square kilometre (DemoIstat, 2014).

Fig. 2. Cagliari's panoramic views.
Source: (1)~~.~~ Municipality of Cagliari, available at~~:~~ http://www.comune.cagliari.it; (2) (3) Authors~~'~~s photos

Fig. 3. Cagliari.

Urban continuity between Cagliari and the surrounding municipalities have created a metropolitan area of 1,114 square kilometres (Figure 3). It is comprised of sixteen municipalities (Cagliari, Assemini, Capoterra, Decimomannu, Elmas, Maracalagonis, Monserrato, Quartu Sant'Elena, Quartucciu, Pula, Sarroch, Selargius, Sestu, Settimo San Pietro, Sinnai, and Villa San Pietro), and a combined population of about 439,100 (DemoIstat, 2014), of which 36.53% are in Cagliari.

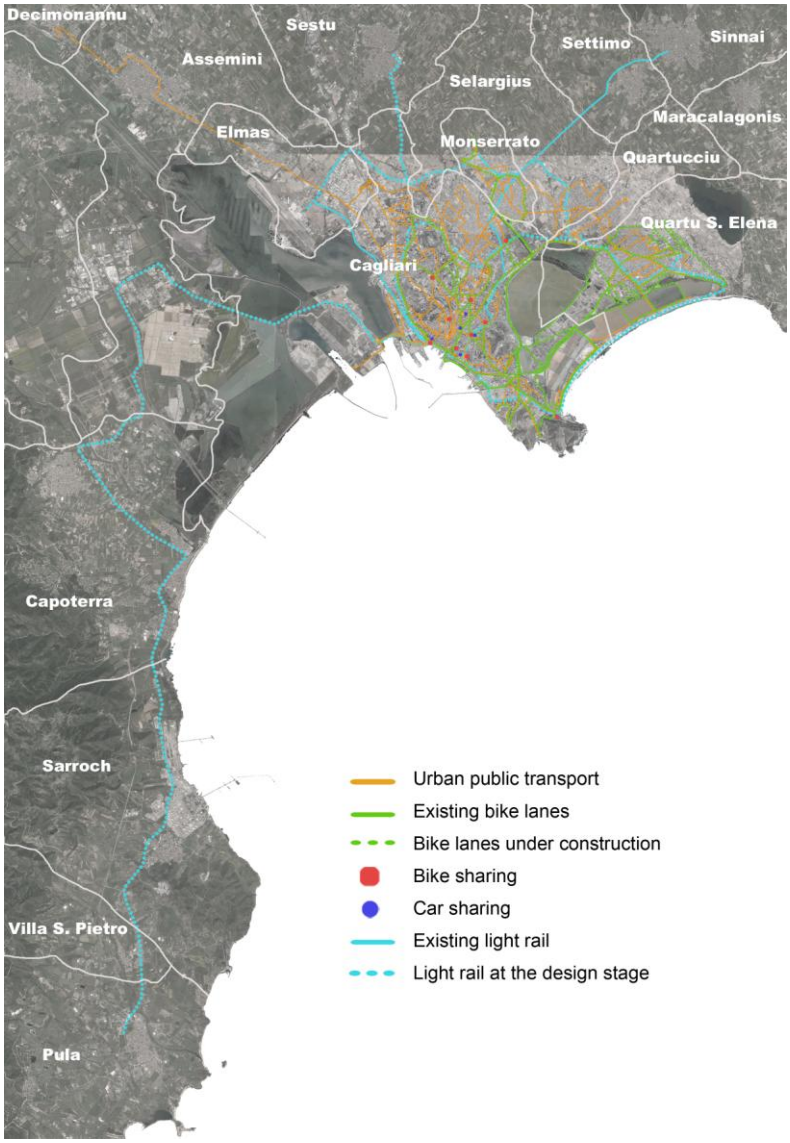

Fig. 4. Public transport network in the metropolitan area of Cagliari.

The main urban planning tool of ~~the~~ Cagliari's metropolitan area is the Intermunicipal Spatial Strategic Plan. It is based on a metropolitan vision focused on smart mobility. This innovative plan guides the territorial development of a wide area~~,~~ in a manner consistent with the new forms of local governance promoted by the EU. In addition, this plan contains two framework agreements pertinent to the governance of mobility in Cagliari titled 'Preliminary Design of a Subway System in the Metropolitan Area of Cagliari' and the 'Integrated Program for Urban Development and Bicycle, Pedestrian and Commuter Mobility in the Metropolitan Area of Cagliari'.

Cagliari has a polycentric configuration, and requires a ~~reorganization~~ reorganisation to recover its historical centrality~~,~~ and enhance relations between south Sardinia's more developed urban centres, through integrated and accessible mobility systems (Tanda, 2014).

Cagliari's ~~'Urban~~ 'Urban Mobility ~~Plan'~~ Plan' (UMP)' describes the current transportation network~~,~~ and how it has evolved. It also outlines the city's transportation objectives, and includes preliminary cost estimates for possible intervention scenarios. In regard to mobility, the main objective of the UMP is to provide support for disabled or old people, pedestrians, and cyclists, to reduce the use of private cars~~,~~ and encourage intermodal bicycle-car-public transport. It recommends interventions that will affect the city's urban features, pre-existing transport networks, and its natural areas of high value that characterize the entire metropolitan area. Pedestrian movements, cyclists, and means of public transport that intersect in many places are being networked. These networks have points of interchange, with stations for bike and car sharing, exchange parking, and public transport stops (bus and light rail). All these services are integrated using technology via smartphone applications, websites, and information boards.

2.1 Cagliari and smart urban mobility

The two framework program agreements mentioned above have allowed the city to begin addressing its transport and mobility problems through the application of integrated strategies that consider the interrelationships between different land uses, the supply of and demand for mobility, and alternative modes of transport. This analysis is possible due to effective coordination between the different local administrative bodies involved.

Cagliari's main mobility strengths are related to the local administration's interest in sustainable mobility, promoting projects needed to realize a network system, policy initiatives that favour alternative modes of mobility, and the ability to interconnect different modes of sustainable transport~~— such as~~ (e.g. intermodal public transport that includes bicycles~~)~~. To date, the city has a cycling network of about 70 kilometres, bike and car sharing services have been activated, and since 2014, tariffs between various public transport operations.

Another strength is the public road transport offered by the Consortium Transport and Mobility CTM (*Consorzio Trasporti e Mobilità*). This management group ranks highly in national service rankings due to its total coverage of the area, and its use of technology to improve services to users (Euromobility, 2014).

A key advantage for Cagliari's mobility is its attractiveness. This aspect is typical for monocentric metropolitan areas. Cagliari's mobility is also characterized by heavy reliance on private transport~~,~~ and a strong demand for mobility conflicts with delays in establishing public transport capabilities and organizing effective mobility, thereby negatively affecting the community's and citizens' economic and social transportation costs.

The demand for improved mobility in the metropolitan area of Cagliari is mainly voiced by commuters from surrounding municipalities~~,~~ and residents who live outside the metropolitan area, who, for reasons of work or study, accounted for 169,815 vehicles/day entering the city, and 131,393 vehicles/day leaving the city, while 61,005 vehicles/day moved within the city centre (Coni, 2014).

This research evaluates the effectiveness of administrative bodies' initiatives to address demands for improved transport~~,~~ by analysing Cagliari's mobility, and conducting an intercity comparison, using quantitative indicators.

3 Applying the methodology in Cagliari

Using the methodology described, we evaluated the merits of the smart mobility services in Cagliari and in comparable urban areas. The first four variables (public transport, cycle lanes, bike sharing, and car sharing) are composed of indicators placed in relation to the population and the territorial extension of the selected case studies. Data from 2014 ~~on selected indicators~~ were collected for selected indicators and then divided into three groups. ~~All data were from 2014.~~

The first group contains data that generate specific measurable indicators. The construction of indicators for public transport ~~are~~ is based on data describing the bus network in relation to its extension in the city, and the number of passengers that use the service in relation to Cagliari's inhabitants.

Indicators for the variable cycle lanes have been identified~~,~~ by comparing the cycle lane network first with the city's areal extent, and then with the number of inhabitants. For the bike sharing variable, the number of stations and the number of available bicycles in relation to the city's extension and to the inhabitants are considered. Finally, for the car sharing variable, data on the number of cars available and the number of stations (by comparing them to the number of inhabitants) were collected. Table 2 summarises these data for Cagliari.

Table 2. Cagliari. Data on measurable indicators.

Cagliari			
• Public Transport			
Bus network density (I_{BND})	→	Bus network	120 km
	→	Area	86.05 km^2
Demand for public transport (I_{DPT})	→	Passengers per year	43.800.000
	→	Inhabitants	385.000
• Cycle lanes			
Cycle lanes density (I_{CLD})	→	Cycle network	70 km
	→	Area	86.05 km^2
Cycle lanes per ten thousand inhabitants (I_{DPT})	→	Cycle network	70 km
	→	Inhabitants	154.019
• Bike Sharing			
Bicycle station density (I_{BSD})	→	N° station	10
	→	Area	86.05 km^2
Bicycle per thousand inhabitants (I_{BPI})	→	N° bicycle	105
	→	Inhabitants	154.019
• Car Sharing			
Car for ten thousand inhabitants(I_{CI})	→	N° car	10
	→	Inhabitants	154.019
Station per thousand inhabitants (I_{SI})	→	N° station	5
	→	Inhabitants	154.019

The second data group concerns the private mobility support system (Table 3) that communicates useful information to users. This includes information concerning traffic, obtained through online dashboards both on-board and outside the vehicles, on panels placed along the streets (variable message signs), or through mobile devices using messaging services or applications (SMS service for traffic alerts, applications for mobile devices). These systems also facilitate payment for parking through electronic devices (electronic payment park systems).

Table 3. Cagliari's private mobility support system.

Cagliari - Private mobility support system	
Variable message sign (I_{VMS})	☺
SMS service for traffic alerts (I_{STA})	☹
Electronic payment park systems (I_{EPPS})	☹
Applications for mobile devices (I_{AMD})	☹
☺ presence of the service	☹ absence of the service

The third data group concerns the public transport support system variable (Table 4). These data represent all those services that help to make public transport a more desirable alternative to private transport (e.g. ~~such as~~ electronic bus stop signs; information on routes, schedules, and waiting times; travel planners for the route calculation). These features give users real-time information regarding the departure and arrival times of trains, trams, and buses. The electronic ticket payment and travel tickets online systems allow users to pay travel fees using smartphones or smart cards that are valid on different means of public transport.

Table 4. Cagliari's public transport support system.

Cagliari - Public transport support system	
Electronic bus stop signs (I_{EBSS})	☺
Electronic ticket payment system (I_{ETPS})	☺
Information on routes, schedules and waiting times (I_{RSWT})	☺
Travel planners for the route calculation (I_{TPC})	☹
Travel tickets online (I_{TTO})	☺
☺ presence of the service	☹ absence of the service

Once all the data and indicators for Cagliari had been identified, they were compared with comparable data for nineteen other international urban contexts with a territorial extension of between 50 and 400 square kilometres (Figure 5).

America	Europe					Africa	Australia
Curitiba	Amsterdam	Copenaghen	Lyon	Salzburg	Turin	Johannesburg	Newcastle
Pittsburgh	Barcellona	Freiburg	Paris	Stuttgart	Treviso		
Vancouver	Cagliari	Lecce	Piacenza	Toulouse			

Fig. 5. Spatial distribution of the cities selected for the ranking.

4 Results ~~of~~ comparing Cagliari to others urban contexts

When comparing Cagliari to others urban contexts, we identified three main problems. The first was finding cities similar to Cagliari. Its size in terms of population and surface area is average for Europe, but small compared to international cities with a minimal level of organization in the field of mobility. The second is a more general problem that relates to data sharing. Although a number of European directives push for the adoption of open and sharing systems, we have not always had easy access to the information needed for this study. The third critical issue concerns finding useful data in a unique form. Information was gathered from various sources, some through publicly available sources (such as web pages, publications, and the so-called mobility card[1]), and others from national statistical agencies or institutional portals.[2] ~~.~~

[1] Regarding public transportation, management companies provide the 'mobility card' on their websites, where transport data for the reference year can be found. For example: CTM Cagliari, (http://www.ctmcagliari.it/);
SGM Lecce, (http://www.sgmlecce.it/index.php/servizi/trasporto-pubblico);
TPL Salzburg (https://www.salzburg-ag.at/unternehmen/zahlen-fakten/);
Movia, Copenhagen (https://ekstranet.moviatrafik.dk/KommuneWeb/Sider/Passagertal.aspx);
Reavaya, Johannesburg, (http://www.reavaya.org.za/welcome).
Data for bike and car sharing services is obtained from company websites (e.g. car2go, Velib Paris, Velov Lyon, Publibike Switzerland, Bicincittà Italia, Stadtmobil Freiburg).

[2] Istat (http://www.istat.it/it/), Statistische Ämter des Bundes und der Länder (http://www.statistikportal.de/Statistik-Portal/), Insee - France (http://www.insee.fr/fr/default.asp), Statistik Austria, (http://www.statistik.at/web_de/statistiken/index.html)

Once all the data required to construct the indicators had been collected, they were standardized by applying Formula 2, and we selected indicators for each variable, by applying Formula 3. Table 5 summarizes the results for the measurable sub-indicators.

Table 5. Measurable sub-indicators and variable aggregations.

Cities	Public transport $I_{PT}=[(I_{BND}+I_{DPT})/2]$			Cycle lanes $I_{CL}=[(I_{CLD}+I_{CLI})/2]$			Bike sharing $I_{BS}=[(I_{BSD}+I_{BPI})/2]$			Car sharing $I_{CS}=[(I_{CI}+I_{SI})/2]$		
	I_{BND}	I_{DPT}	**I_{PT}**	I_{CLD}	I_{CLI}	**I_{CL}**	I_{BSD}	I_{BPI}	**I_{BS}**	I_{CI}	I_{SI}	**I_{CS}**
Amsterdam	0,22	6,76	3,49	1,64	2,82	2,23	0,01	2,01	1,01	2,58	4,00	3,29
Barcelona	10,55	9,01	9,78	0,50	0,01	0,25	2,40	3,02	2,71	0,58	0,63	0,60
Cagliari	**0,87**	**2,72**	**1,79**	**0,59**	**2,42**	**1,51**	**0,06**	**0,55**	**0,31**	**0,45**	**0,47**	**0,46**
Copenaghen	5,53	8,78	7,15	3,50	3,30	3,40	0,11	0,20	0,15	3,21	1,83	2,52
Freiburg	1,67	8,86	5,27	2,27	10,00	6,14	0,03	0,37	0,20	8,14	4,70	6,42
Lecce	1,34	0,01	0,67	0,01	2,57	1,29	0,01	0,85	0,43	0,60	0,16	0,38
Lyon	10,00	6,76	8,38	10,00	6,32	8,16	4,21	6,63	5,42	1,81	0,20	1,01
Paris	8,01	2,61	5,31	3,11	0,69	1,90	10,00	8,57	9,28	7,66	5,59	6,62
Piacenza	0,62	1,78	1,20	0,42	4,07	2,25	0,01	0,50	0,25	0,01	0,01	0,01
Salzburg	2,02	2,16	2,09	2,43	1,75	2,09	0,08	2,29	1,18	0,20	0,19	0,19
Stuttgart	3,36	9,88	6,62	0,55	1,34	0,94	0,16	0,55	0,36	5,46	5,57	5,52
Toulouse	1,85	2,44	2,15	3,70	6,17	4,94	1,38	10,00	5,69	0,68	0,68	0,68
Turin	6,33	5,52	5,93	1,08	0,88	0,98	0,47	1,47	0,97	0,93	1,22	1,08
Treviso	1,17	2,29	1,73	0,83	3,94	2,39	0,17	1,50	0,83	0,01	0,01	0,01
Curitiba	2,39	10,00	6,19	0,19	0,31	0,25	0,01	0,55	0,28	0,04	0,06	0,05
Pittsburgh	6,02	5,38	5,70	0,64	2,26	1,45	0,18	1,33	0,76	1,09	1,37	1,23
Vancouver	4,21	5,05	4,63	2,03	2,32	2,17	0,01	0,01	0,01	10,00	10,00	10,00
Johannesburg	0,30	0,53	0,41	0,73	0,35	0,54	0,01	0,01	0,01	0,01	0,01	0,01
Newcastle	0,01	1,06	0,53	0,54	3,55	2,04	0,01	0,02	0,02	0,01	0,01	0,01

Analysis of the variables shows that even though Cagliari is well equipped with transport services, it always ranks in the middle when compared to selected case studies. Regarding public transport, Lyon, Barcelona, and Copenhagen are the most progressive. For cycle lanes, Lyon, Freiburg, and Toulouse are the most progressive cities, for bike sharing, Paris, Toulouse, and Lyon are the most progressive cities, and for car sharing, Vancouver, Paris, and Freiburg are the most progressive. European cities ranked highest for transport equipment, with the exception of the car sharing variable, for which Vancouver is the most highly ranked. Cities with the lowest equipment ranking are Johannesburg in Africa, and Newcastle (NSW) in Australia. Table 6 summarizes the standardized binary sub-indicators—on/off—and the related indicators for the private mobility support system and public transport support system variables.

Table 6. Binary indicators and variable aggregations.

Cities	Private mobility support system $I_{PMSS}=[(I_{VMS}+I_{STA}+I_{EPPS}+I_{AMD})/4]$					Public transport support system $I_{PTS}=[(I_{EBSS}+I_{ETPS}+I_{RSWT}+I_{TPC}+I_{TTO})/5]$					
	I_{VMS}	I_{STA}	I_{EPPS}	I_{AMD}	**I_{PMSS}**	I_{EBSS}	I_{ETPS}	I_{RSWT}	I_{TPC}	I_{TTO}	**I_{PTSS}**
Amsterdam	10,00	10,00	10,00	10,00	10,00	10,00	0,00	10,00	10,00	10,00	8,00
Barcellona	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Cagliari	**10,00**	**0,00**	**0,00**	**0,00**	**2,50**	**10,00**	**10,00**	**10,00**	**0,00**	**10,00**	**8,00**
Copenaghen	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Freiburg	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Lecce	10,00	0,01	10,00	0,01	5,01	10,00	10,00	10,00	0,01	10,00	8,00
Lyon	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Paris	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Piacenza	10,00	0,01	0,01	0,01	2,51	0,01	10,00	0,01	0,01	10,00	4,01
Salzburg	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Stuttgart	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Toulouse	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	0,01	8,00
Turin	10,00	0,01	10,00	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Treviso	10,00	0,01	10,00	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Curitiba	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Pittsburgh	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Vancouver	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	0,01	8,00
Johannesburg	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	0,01	8,00
Newcastle	10,00	0,01	0,01	10,00	5,01	10,00	10,00	10,00	10,00	10,00	10,00

The data for the on/off binary indicators show that almost all European cities are well equipped with private mobility support systems, even if Cagliari, like Piacenza, is one of the less ~~well~~ well-equipped cities. American cities are well equipped with private mobility support systems, while Johannesburg and Newcastle (NWS) rank below the European average.

The situation improves for equipment associated with the public transport support system, and there is excellent equipment for most of the case studies. Regarding European cities, most, including Cagliari, are well equipped. American, African, and Australian cities are well equipped for a public transport support system.

Table 7 presents the results obtained for each individual variable. It summarizes the results of analysing the synthetic indicator of smart mobility~~,~~ by aggregating all seventeen sub-indicators that comprise the six individual variables. It is obtained applying Formula 1.

Table 7. The Smart Mobility synthetic indicator.

Cities	Smart mobility $I_{SM}=[(I_{PT}*I_{CL}*I_{BS}*I_{CS}*I_{PMSS}*I_{PTSS})^{\wedge(1/6)}$						
	I_{PT}	I_{CL}	I_{BS}	I_{CS}	I_{PMSS}	I_{PTSS}	**I_{SM}**
Paris	5,31	1,90	9,28	6,62	10,00	10,00	6,29
Lyon	8,38	8,16	5,42	1,01	10,00	10,00	5,78
Freiburg	5,27	6,14	0,20	6,42	10,00	10,00	4,00
Toulouse	2,15	4,94	5,69	0,68	7,50	8,00	3,68
Amsterdam	3,49	2,23	1,01	3,29	10,00	8,00	3,57
Copenaghen	7,15	3,40	0,15	2,52	10,00	10,00	3,12
Stuttgart	6,62	0,94	0,36	5,52	7,50	10,00	3,12
Pittsburgh	5,70	1,45	0,76	1,23	10,00	10,00	3,02
Turin	5,93	0,98	0,97	1,08	7,50	10,00	2,77
Barcelona	9,78	0,25	2,71	0,60	10,00	10,00	2,72
Salzburg	2,09	2,09	1,18	0,19	10,00	10,00	2,15
Vancouver	4,63	2,17	0,01	10,00	10,00	8,00	2,08
Cagliari	**1,79**	**1,51**	**0,31**	**0,46**	**2,50**	**8,00**	**1,40**
Lecce	0,67	1,29	0,43	0,38	5,01	8,00	1,34
Treviso	1,73	2,39	0,83	0,01	7,50	10,00	1,14
Curitiba	6,19	0,25	0,28	0,05	7,50	10,00	1,09
Piacenza	1,20	2,25	0,25	0,01	2,51	4,01	0,62
Newcastle	0,53	2,04	0,02	0,01	5,01	10,00	0,46
Johannesburg	0,41	0,54	0,01	0,01	7,50	8,00	0,33

The first seven positions are occupied by European cities that achieve a relatively high score for almost all the variables analysed. The first American city appears in the eighth position (Pittsburgh). Cagliari is ranked thirteenth. Despite Cagliari's many advances in the field of mobility, the Sardinian capital has not yet implemented accepted best practices of sustainable mobility. Although Curitiba ranks highly for public transport, it is not ranked highly for the other variables. Piacenza, Newcastle, and Johannesburg are at the bottom of the ranking~~,~~ because some services (such as bike and car sharing) are not yet available ~~(such as bike and car sharing)~~, and the others do not have a good distribution.

4.1 Intercity comparison based on individual variables

After identifying the smart mobility synthetic indicator, some indicators closely linked to the people who use these services were analysed. In particular, the variables of public transport, cycle lanes, bike sharing and car sharing were analysed. For each variable, comparisons between the studied cities were graphically represented. As previously explained, the second quadrant defines the optimal situation for the public transport variable, because a smaller but heavily used network is more effective than a large and lightly used infrastructure. In Figure 6, Cagliari ranks in the third quadrant, just below the second one, despite the enormous progress that city has made in public transport. Two European cities (Amsterdam and Freiburg) have the best situations.

The cities that fall in the first quadrant have significant infrastructure endowments: these include five European cities (Barcelona, Copenhagen, Lyon, Stuttgart, and Turin), and three American cities (Curitiba, Pittsburgh, and Vancouver).

Australian and African cities rank in the third quadrant, because they have an underdeveloped and underutilized network of public transport.

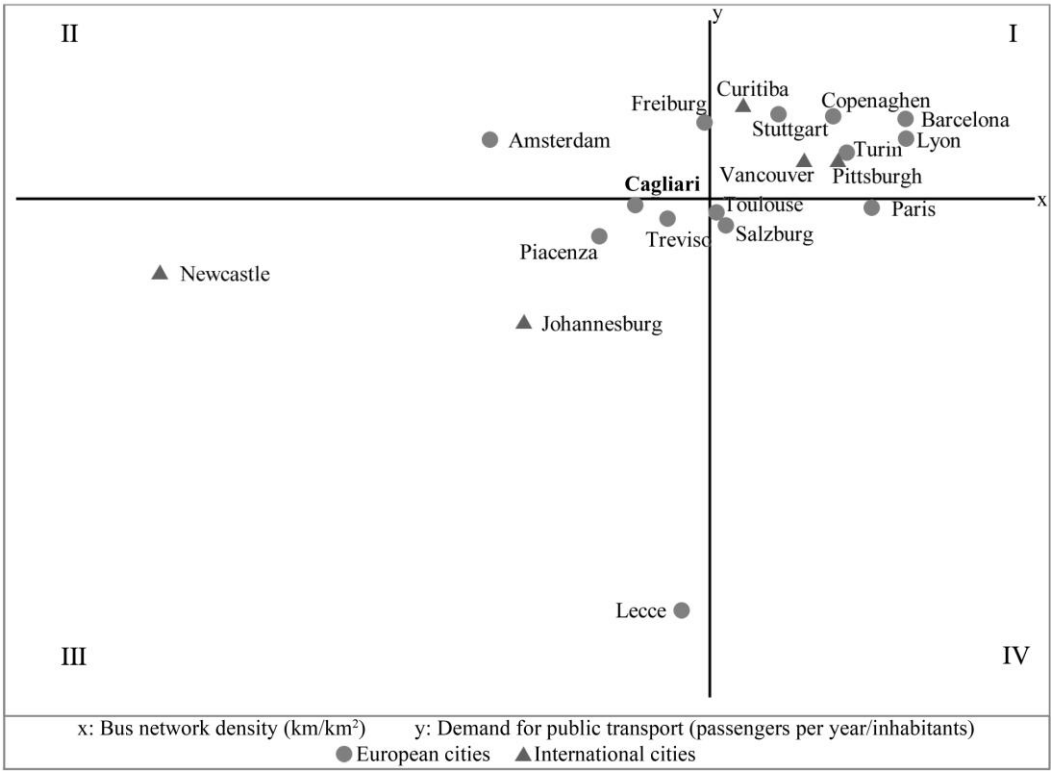

Fig. 6. Intercity comparison of the public transport variable.

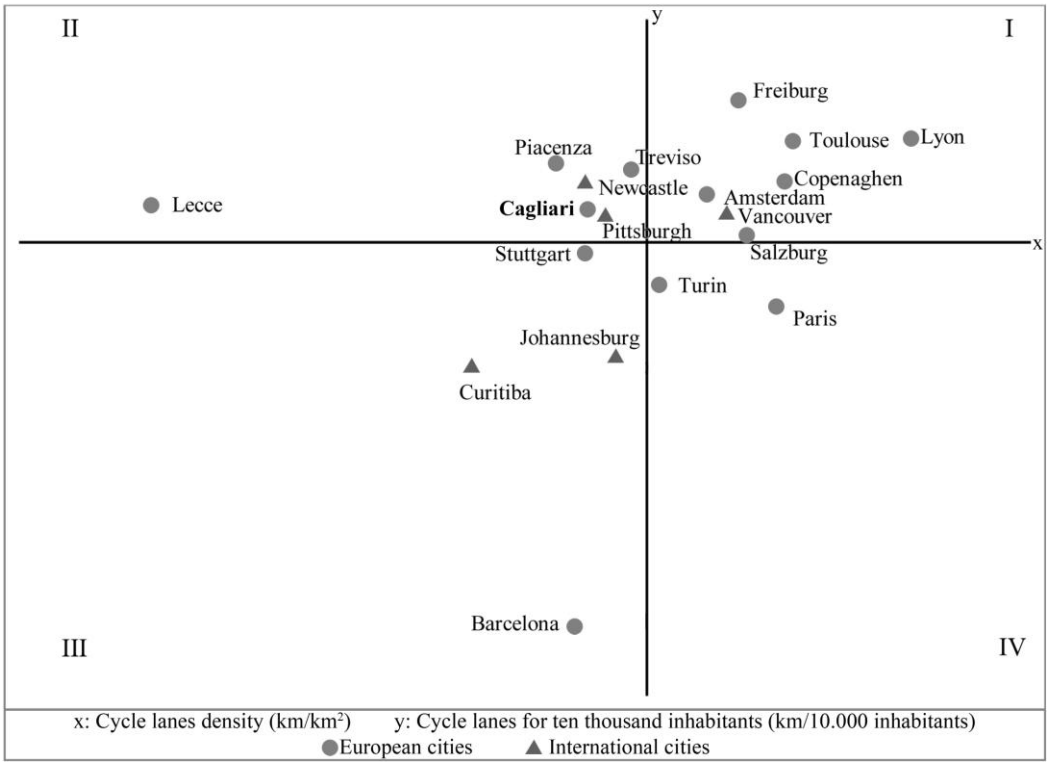

Fig. 7. Intercity comparison of the cycle lanes variable.

Regarding the cycle lanes variable, quadrant one represents the optimal situation, because a continuous and very extended network will support their use. In Figure 7, six European cities fall in this quadrant (Freiburg, Toulouse, Lyon, Copenhagen, Amsterdam, and Salzburg), and one American city (Vancouver). Cagliari has a good extension of this network relative to its territorial surface, but it is still not optimal when compared to the number of its inhabitants. Barcelona has the worst situation for bicycle lanes, with Curitiba and Johannesburg also falling in this quadrant.

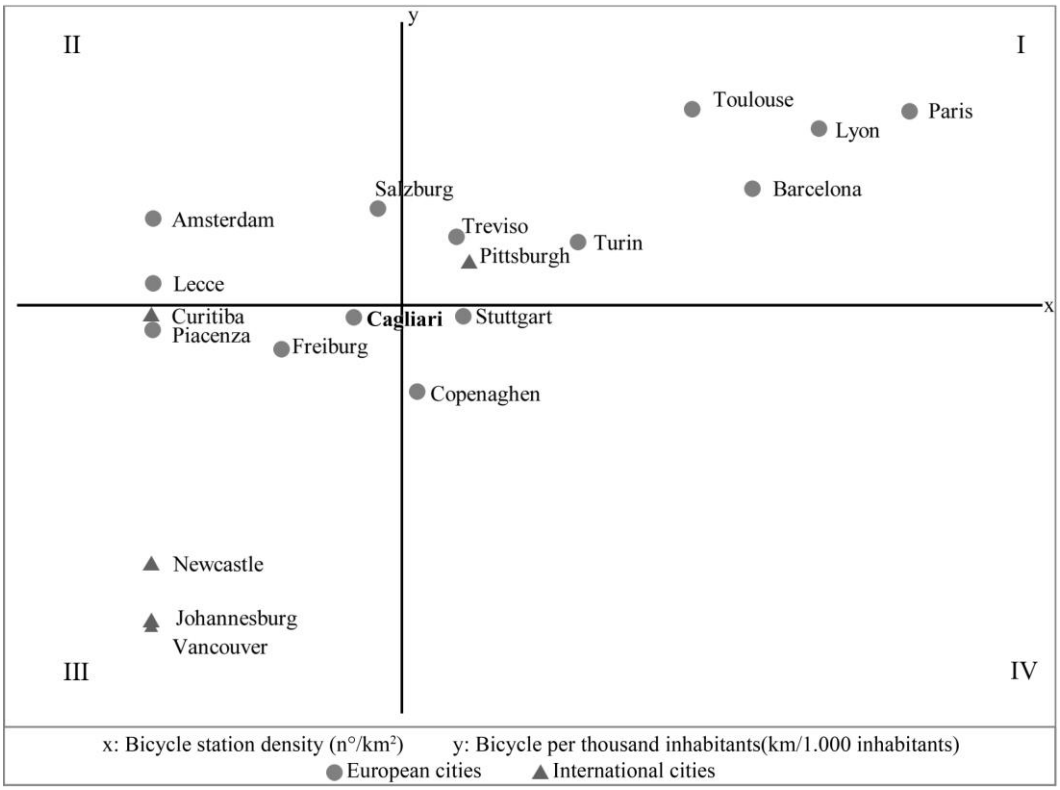

Fig. 8. Intercity comparison of the bike sharing variable.

Regarding the bike sharing variable, the optimal situation again falls in the first quadrant, where, as shown in Figure 8, we find six European cities (Paris, Toulouse, Lyon, Barcelona, Turin, and Treviso) and one American city (Pittsburgh). Cagliari appears in the third quadrant, despite having recently increased the number of its cycle-stations, but the availability of bikes is lacking compared to other cities. Johannesburg and Vancouver do not have a bike sharing service.

Regarding the car sharing variable, the optimal situation occurs in the first quadrant, where, as shown in Figure 9, the majority of European cities and two American cities (Pittsburgh and Vancouver) fall. Cagliari is in the second quadrant, because this service was initiated only recently, and is still being expanded. Cities that do not yet have this service are Piacenza, Treviso, Newcastle, and Johannesburg.

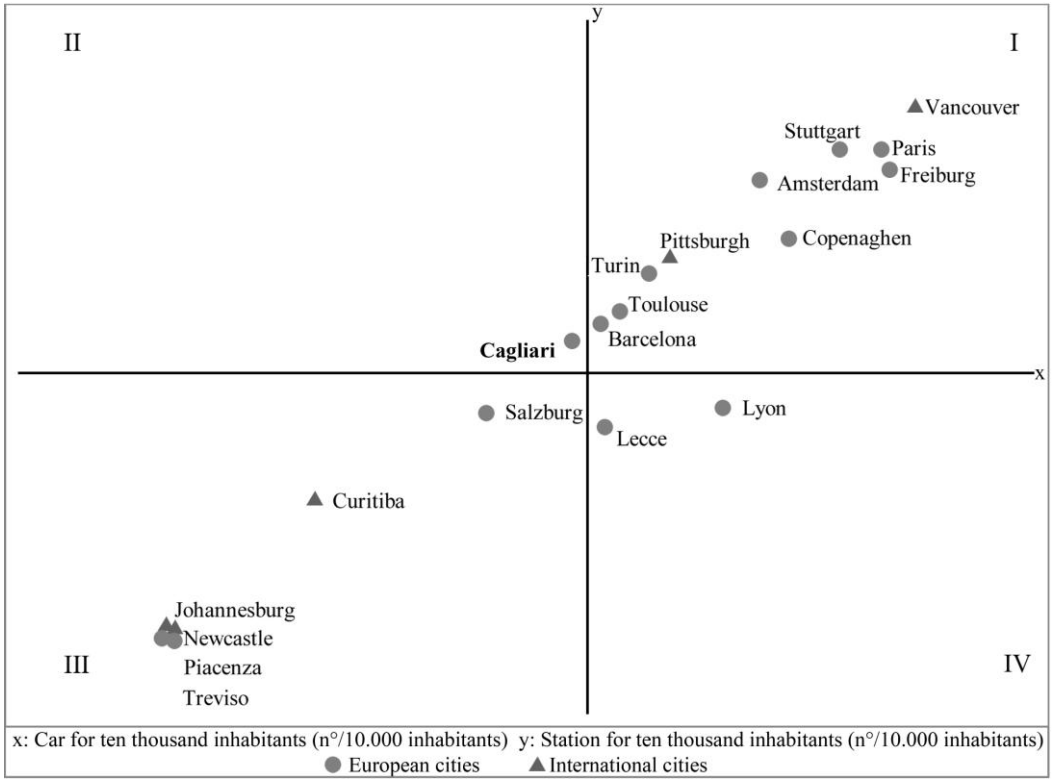

Fig. 9. Intercity comparison of the car sharing variable.

5 Discussion

In this study, the authors analysed various international cities by selecting indicators, the choice of which depended primarily on data for the urban contexts studied. It was found that, at least in the field of mobility, sufficient data sharing has not yet been achieved. The choice of graphically representing each variable in quadrants has prompted the authors to ask whether one could analyse the quality of the values obtained, in relation to a representative area of balanced policies, on the basis of actions already in place. In fact, the graphical representation of the variables may be a starting point for beginning to understand whether investments taken hitherto for smart mobility have coherence and logic. For example, in Figure 6, the variable public transport is analysed by comparing the availability of the network to the use of the same network. Cities that are closest to the diagonal of quadrants I and III have a more balanced situation, than those who have a very extensive and poorly used network or vice versa, or that have a position close to the axes of quadrants.

The cycle lanes, bike, and car sharing variables are compared with the least number of possible users of the service (inhabitants). Also in this case, cities that are positioned close to the diagonals of quadrants I and III have invested in that sector and obtained balanced results. It is interesting to note that cities with services managed privately (mainly for the car sharing variable, Figure 9) are positioned along the diagonals of quadrants I and III, surely because the private

sector maximizes investments, and therefore invests in a more balanced way, so as to ensure both good service and fair economic returns.

6 Conclusions

This research addresses a topical theme in contemporary literature. In fact, the smartness of cities and comparisons between them can provide an excellent tool for evaluating policy implementation in terms of smart cities, and this constant monitoring allows city planners to move towards smart urbanism. The first step of this research was to analyse mobility in the city of Cagliari through the selection of appropriate indicators, and to apply the described methodology. Results of the analysis show that Cagliari cannot yet be described as exemplifying best practices in the smart mobility sector, although in recent years several projects in the field of sustainable mobility have been activated, and have provided significant improvements to the city. This is because Cagliari, in comparison to other cities, is paying for a significant delay in the organization of its transportation services, and has only recently taken concrete actions on soft mobility, in contrast to the majority of European cities, which have a decennial culture of soft mobility. Strengthening the process of adapting the facilities and services related to mobility is therefore essential, while focusing on the nature of competitiveness that already characterizes the territory.

It was possible to compare ~~Cagliari's~~ Cagliari's smart mobility with that in other international centres, and generate a cities' ranking (Table 7). This comparison allowed the researchers to make the following recommendations for improving ~~Cagliari's~~ Cagliari's mobility.

- Given that public transport in Cagliari has, in recent years, achieved excellent quality levels, further improvements could be realized by integrating the tariff that today applies only to buses and the metro with other transportation services. For example, other cities such as Paris, Amsterdam, and Turin are proposing a single user card for all transportation services, including bike and car sharing.
- The terminus of a few lines could be linked with the metro stations (as in Barcelona, Paris, Lyon, Curitiba, and Stuttgart), thus creating more intermodal nodes useful for the rationalisation of the various services, and creating more possibilities for interchanges between private/public means.
- With regard to bike lanes, Cagliari could adopt the Danish administration's approach to encourage cycling, by creating real highways for bicycles, providing parking decks for bikes throughout the city, and so discouraging the use of private vehicles.

- Further regarding bike sharing, Cagliari could follow the examples of Paris, Lyon, and Toulouse (the best performing cities in our mobility ranking list, Table 7) and provide stations with kiosks, where rentals and subscription services can be completed (without having to attend a special office), every 300 metres. Doing so would encourage greater use of these services.
- The same arrangements could be used for car sharing, for which Vancouver has the largest number of available stations. Vehicles are also available at short ~~300~~ 300-metre intervals, thereby enabling users to have ready access to use them.
- In addition, Cagliari officials should increase the city's electric mobility capabilities, and install numerous conveniently located recharging stations for private vehicles in the metropolitan area, and increase car sharing capabilities with electric vehicles.

This paper has revealed that the methodology used can be applied to evaluate other elements of smartness than mobility (such as the economy, the environment, and the governance of cities). Being able to precisely measure the levels of smartness in the city allows planners to constantly monitor the governance actions taken by administrative authorities, and to assess the effectiveness of these interventions for improving the quality of life, which is the central theme of contemporary political development in the urban field of smart cities.

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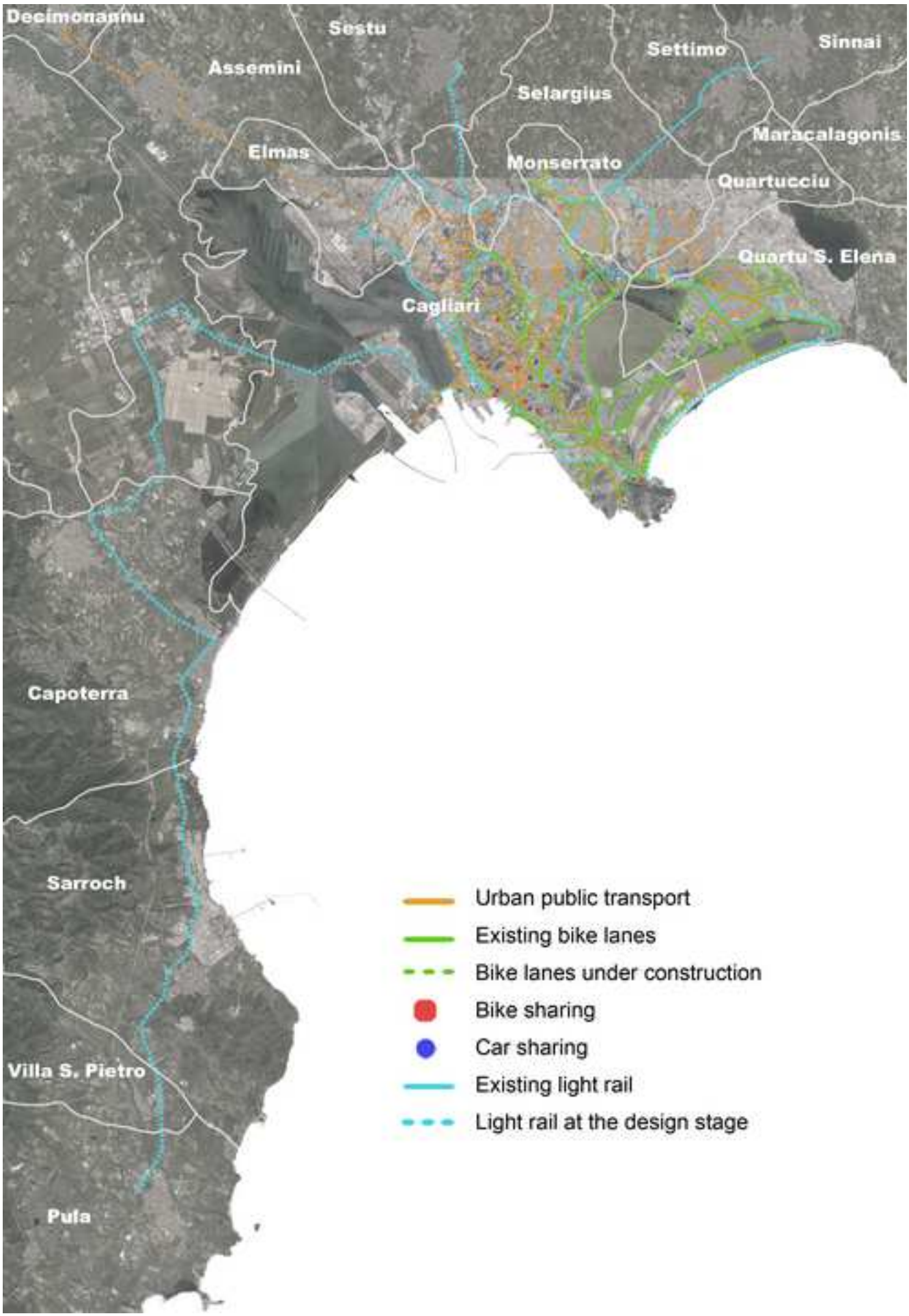

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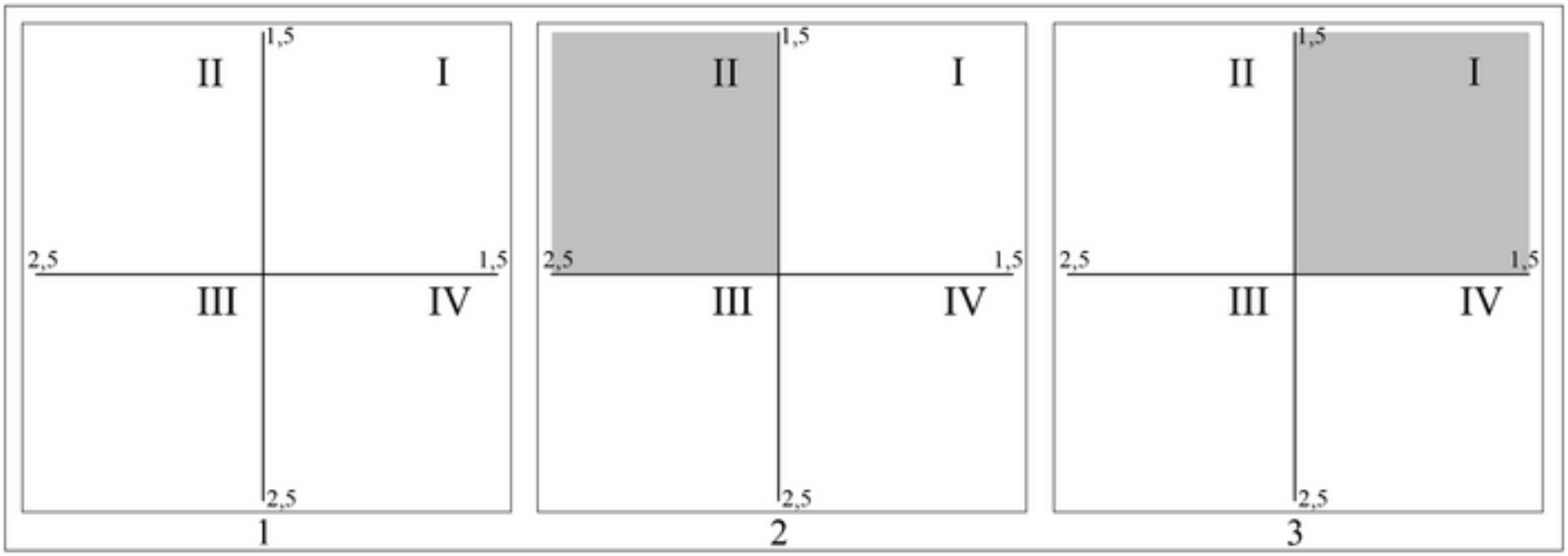

Figure
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America	Europe					Africa	Australia
Curitiba	Amsterdam	Copenaghen	Lyon	Salzburg	Turin	Johannesburg	Newcastle
Pittsburgh	Barcellona	Freiburg	Paris	Stuttgart	Treviso		
Vancouver	Cagliari	Lecce	Piacenza	Toulouse			

Figure06

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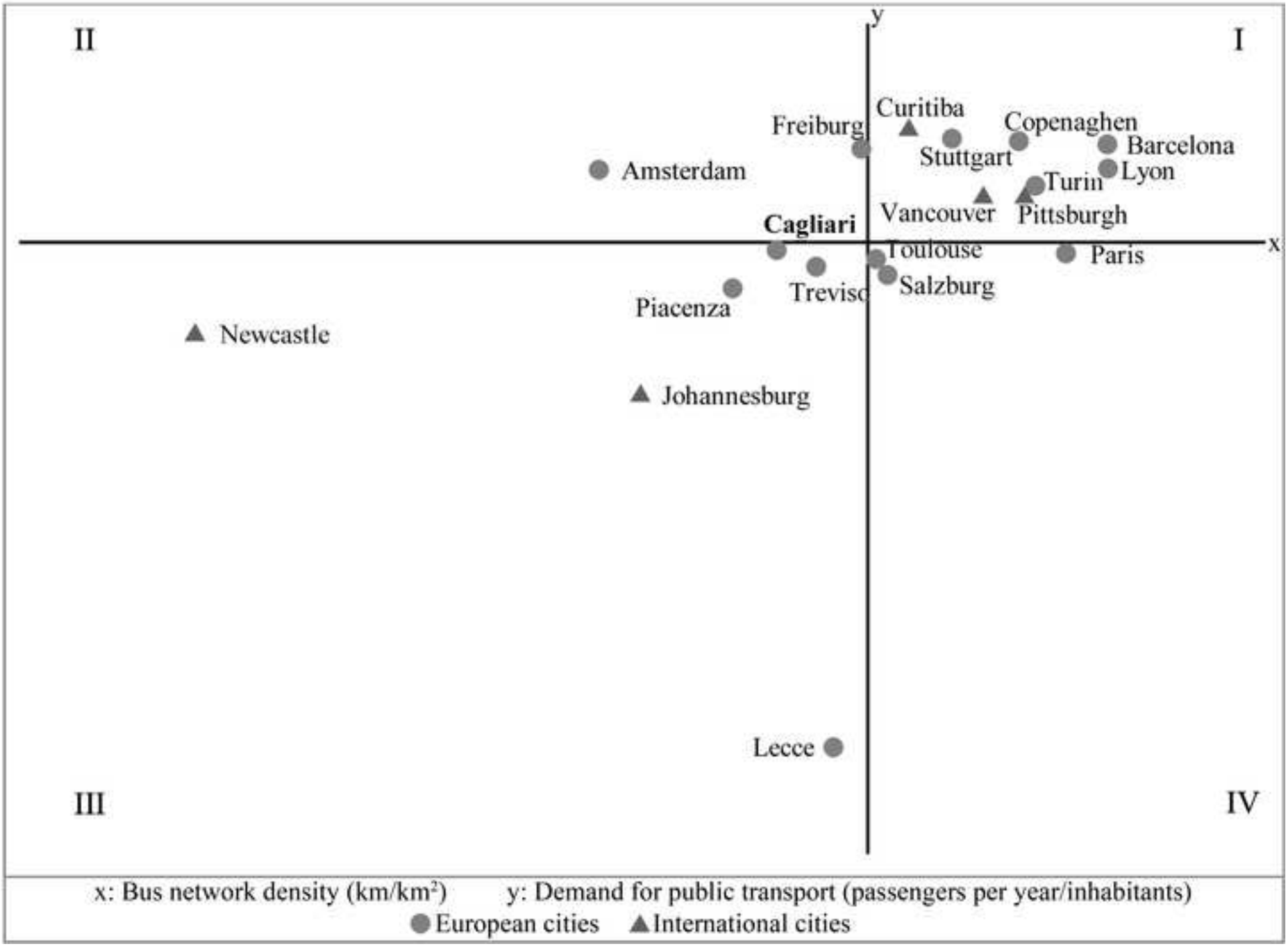

Figure07

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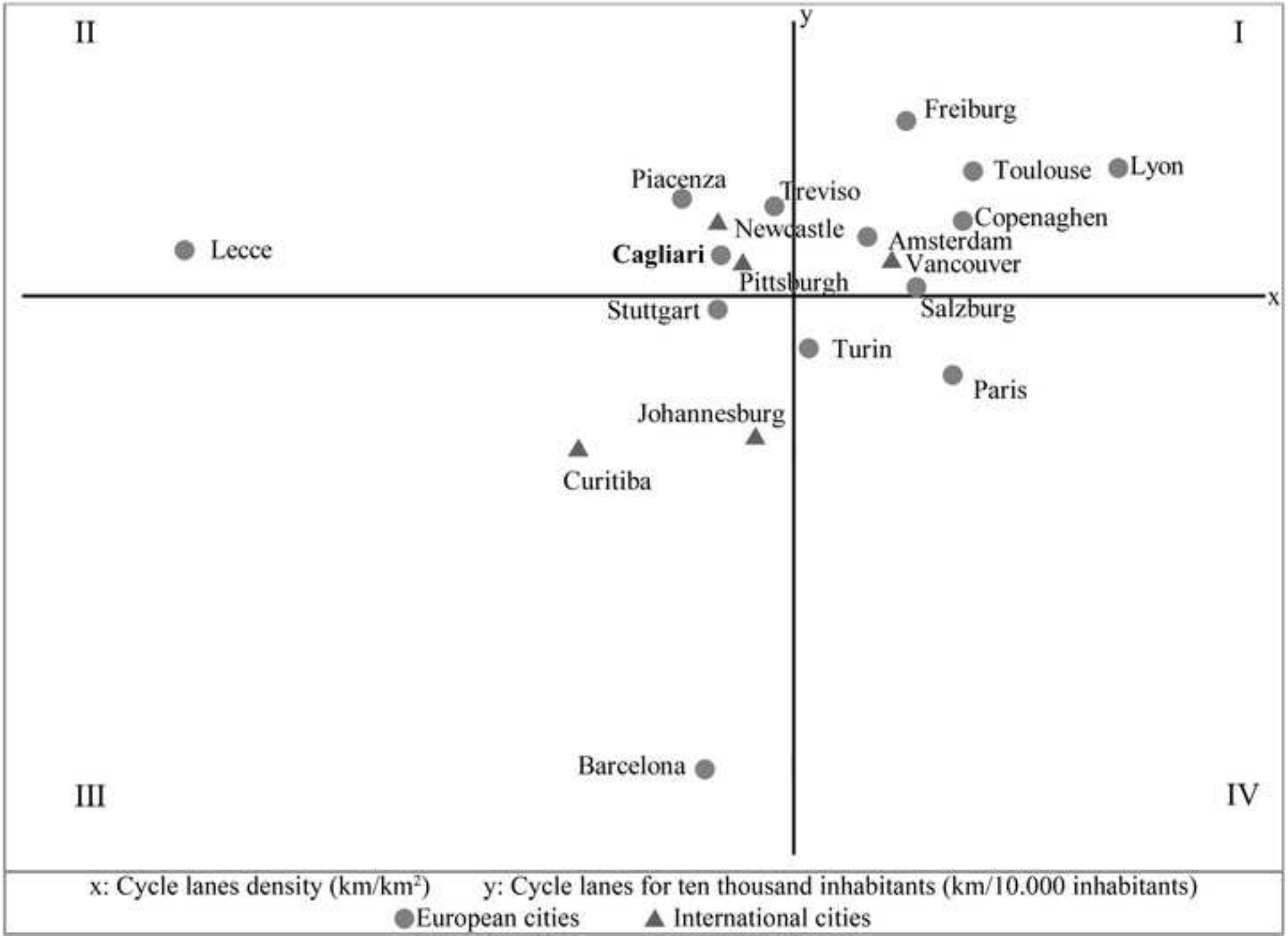

Figure08
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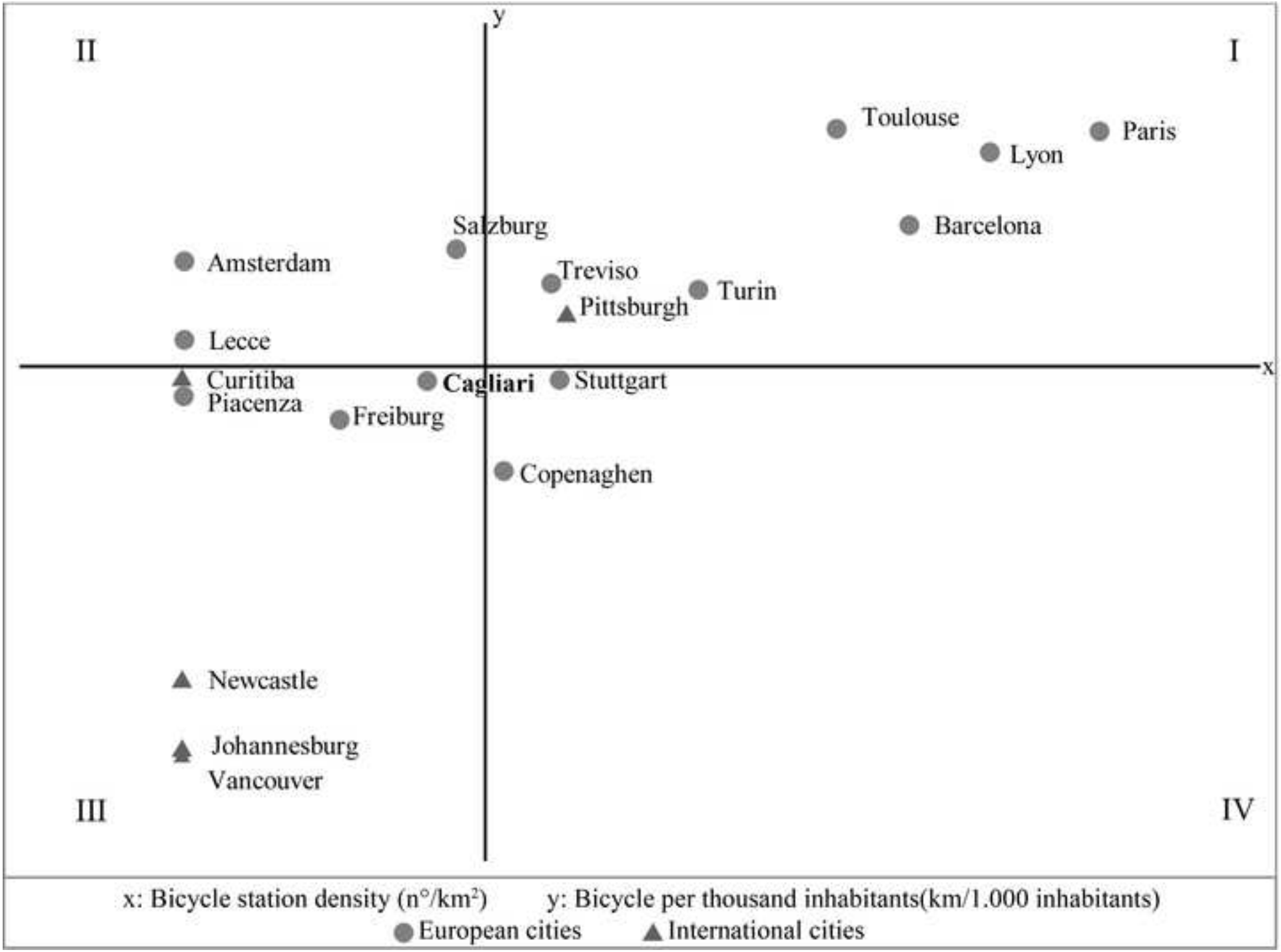

Figure09

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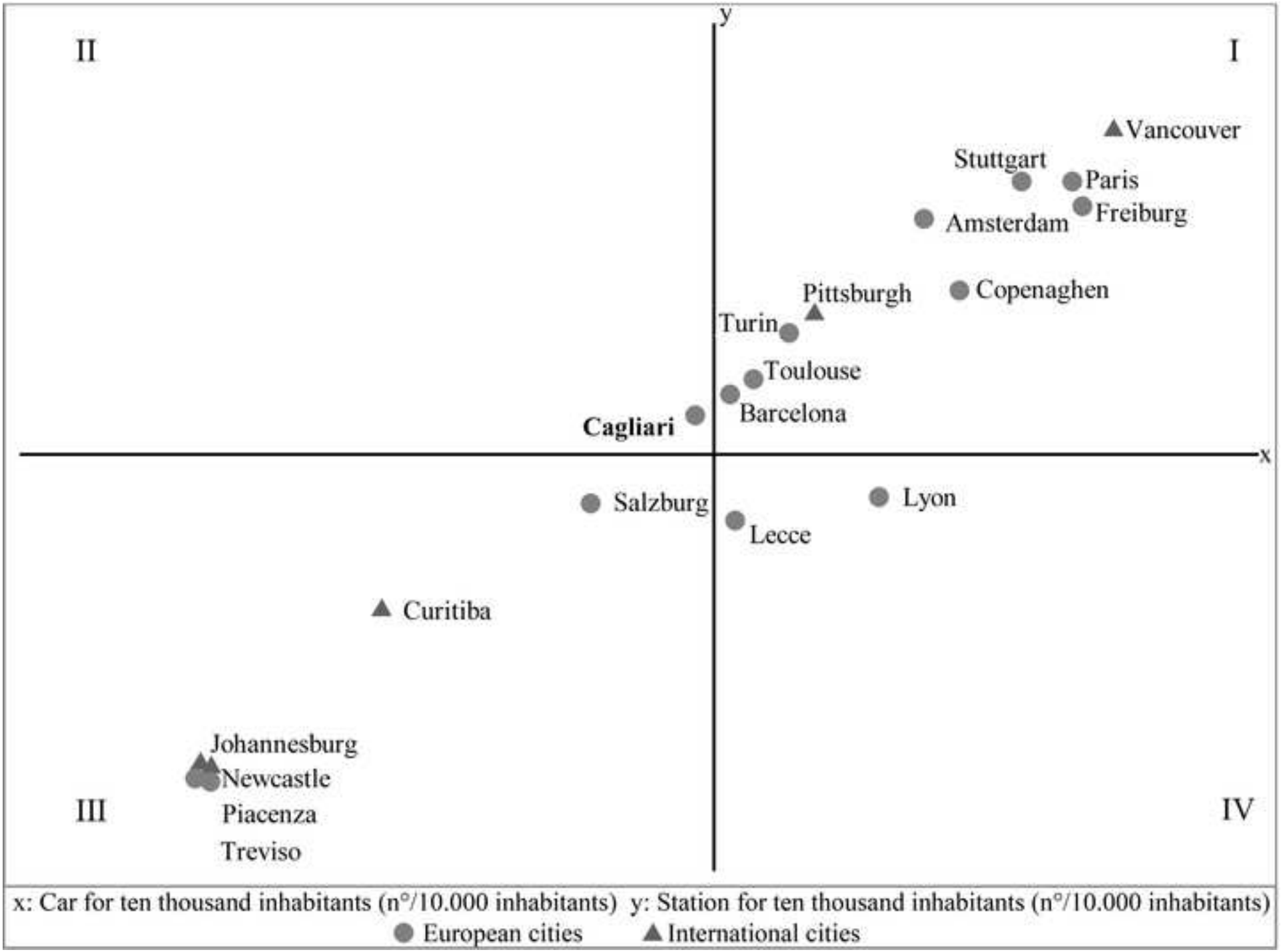

Table

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Variables	*Indicators*	*Sub-Indicators*		*Unit*
Public transport	I_{PT}	I_{BND}	Bus network density	km/100 km^2
		I_{DPT}	Demand for public transport	passengers per year/inhabitants
Cycle lanes	I_{CL}	I_{CLD}	Cycle lanes density	km/100 km^2
		I_{CLI}	Cycle lanes for ten thousand inhabitants	km/10.000 inhabitants
Bike sharing	I_{BS}	I_{BSD}	Bicycle station density	n°/km^2
		I_{BPI}	Bicycle per thousand inhabitants	n°/1.000 inhabitants
Car sharing	I_{CS}	I_{CI}	Car for ten thousand inhabitants	n°/10.000 inhabitants
		I_{SI}	Station for ten thousand inhabitants	n°/10.000 inhabitants
Private mobility support system	I_{PMSS}	I_{VMS}	Variable message sign	yes=1,00; no=0,00
		I_{STA}	SMS service for traffic alerts	yes=1,00; no=0,00
		I_{EPPS}	Electronic payment park systems	yes=1,00; no=0,00
		I_{AMD}	Applications for mobile devices	yes=1,00; no=0,00
Public transport support system	I_{PTSS}	I_{EBSS}	Electronic bus stop signs	yes=1,00; no=0,00
		I_{ETPS}	Electronic ticket payment system	yes=1,00; no=0,00
		I_{RSWT}	Information on routes, schedules and waiting times	yes=1,00; no=0,00
		I_{TPC}	Travel planner for the route calculation	yes=1,00; no=0,00
		I_{TTO}	Travel tickets online	yes=1,00; no=0,00

Table

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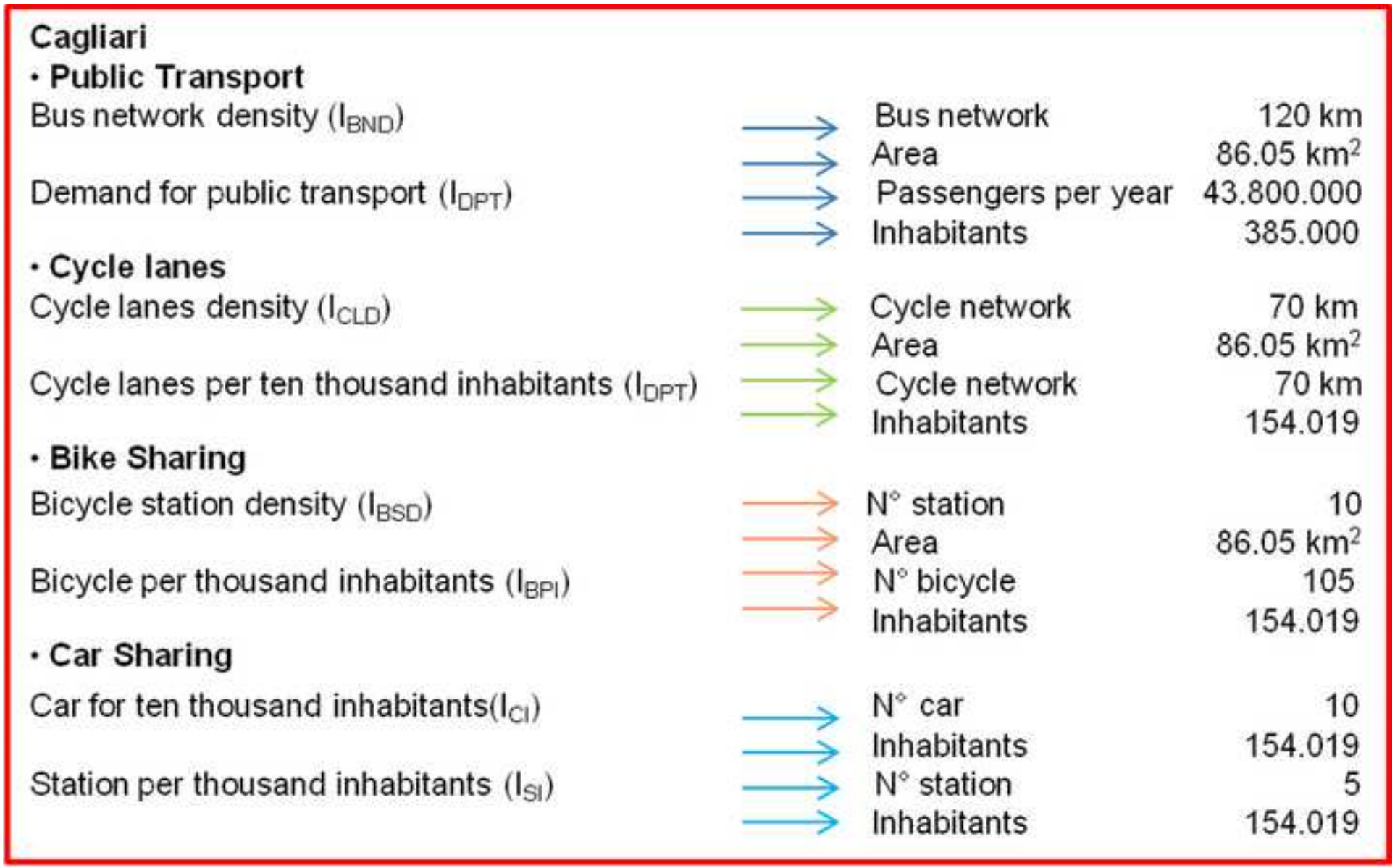

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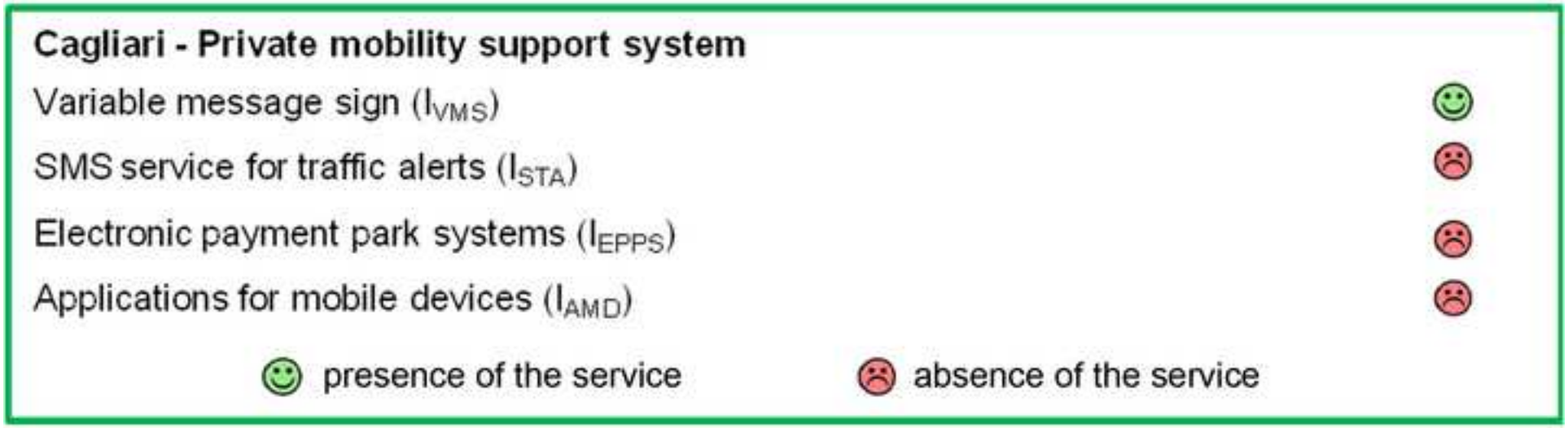

Table

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Cagliari - Public transport support system

Electronic bus stop signs (I_{EBSS})	☺
Electronic ticket payment system (I_{ETPS})	☺
Information on routes, schedules and waiting times (I_{RSWT})	☺
Travel planners for the route calculation (I_{TPC})	☹
Travel tickets online (I_{TTO})	☺

☺ presence of the service ☹ absence of the service

Table

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Cities	Public transport $I_{PT}=[(I_{BND}+I_{DPT})/2]$			Cycle lanes $I_{CL}=[(I_{CLD}+I_{CLI})/2]$			Bike sharing $I_{BS}=[(I_{BSD}+I_{BPI})/2]$			Car sharing $I_{CS}=[(I_{CI}+I_{SI})/2]$		
	I_{BND}	I_{DPT}	$\mathbf{I_{PT}}$	I_{CLD}	I_{CLI}	$\mathbf{I_{CL}}$	I_{BSD}	I_{BPI}	$\mathbf{I_{BS}}$	I_{CI}	I_{SI}	$\mathbf{I_{CS}}$
Amsterdam	0,22	6,76	3,49	1,64	2,82	2,23	0,01	2,01	1,01	2,58	4,00	3,29
Barcelona	10,55	9,01	9,78	0,50	0,01	0,25	2,40	3,02	2,71	0,58	0,63	0,60
Cagliari	**0,87**	**2,72**	**1,79**	**0,59**	**2,42**	**1,51**	**0,06**	**0,55**	**0,31**	**0,45**	**0,47**	**0,46**
Copenaghen	5,53	8,78	7,15	3,50	3,30	3,40	0,11	0,20	0,15	3,21	1,83	2,52
Freiburg	1,67	8,86	5,27	2,27	10,00	6,14	0,03	0,37	0,20	8,14	4,70	6,42
Lecce	1,34	0,01	0,67	0,01	2,57	1,29	0,01	0,85	0,43	0,60	0,16	0,38
Lyon	10,00	6,76	8,38	10,00	6,32	8,16	4,21	6,63	5,42	1,81	0,20	1,01
Paris	8,01	2,61	5,31	3,11	0,69	1,90	10,00	8,57	9,28	7,66	5,59	6,62
Piacenza	0,62	1,78	1,20	0,42	4,07	2,25	0,01	0,50	0,25	0,01	0,01	0,01
Salzburg	2,02	2,16	2,09	2,43	1,75	2,09	0,08	2,29	1,18	0,20	0,19	0,19
Stuttgart	3,36	9,88	6,62	0,55	1,34	0,94	0,16	0,55	0,36	5,46	5,57	5,52
Toulouse	1,85	2,44	2,15	3,70	6,17	4,94	1,38	10,00	5,69	0,68	0,68	0,68
Turin	6,33	5,52	5,93	1,08	0,88	0,98	0,47	1,47	0,97	0,93	1,22	1,08
Treviso	1,17	2,29	1,73	0,83	3,94	2,39	0,17	1,50	0,83	0,01	0,01	0,01
Curitiba	2,39	10,00	6,19	0,19	0,31	0,25	0,01	0,55	0,28	0,04	0,06	0,05
Pittsburgh	6,02	5,38	5,70	0,64	2,26	1,45	0,18	1,33	0,76	1,09	1,37	1,23
Vancouver	4,21	5,05	4,63	2,03	2,32	2,17	0,01	0,01	0,01	10,00	10,00	10,00
Johannesburg	0,30	0,53	0,41	0,73	0,35	0,54	0,01	0,01	0,01	0,01	0,01	0,01
Newcastle	0,01	1,06	0,53	0,54	3,55	2,04	0,01	0,02	0,02	0,01	0,01	0,01

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Cities	Private mobility support system $I_{PMSS}=[(I_{VMS}+I_{STA}+I_{EPPS}+I_{AMD})/4]$					Public transport support system $I_{PTS}=[(I_{EBSS}+I_{ETPS}+I_{RSWT}+I_{TPC}+I_{TTO})/5]$					
	I_{VMS}	I_{STA}	I_{EPPS}	I_{AMD}	**I_{PMSS}**	I_{EBSS}	I_{ETPS}	I_{RSWT}	I_{TPC}	I_{TTO}	**I_{PTSS}**
Amsterdam	10,00	10,00	10,00	10,00	10,00	10,00	0,00	10,00	10,00	10,00	8,00
Barcellona	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Cagliari	**10,00**	**0,00**	**0,00**	**0,00**	**2,50**	**10,00**	**10,00**	**10,00**	**0,00**	**10,00**	**8,00**
Copenaghen	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Freiburg	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Lecce	10,00	0,01	10,00	0,01	5,01	10,00	10,00	10,00	0,01	10,00	8,00
Lyon	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Paris	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Piacenza	10,00	0,01	0,01	0,01	2,51	0,01	10,00	0,01	0,01	10,00	4,01
Salzburg	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Stuttgart	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Toulouse	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	0,01	8,00
Turin	10,00	0,01	10,00	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Treviso	10,00	0,01	10,00	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Curitiba	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	10,00	10,00
Pittsburgh	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00
Vancouver	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	10,00	0,01	8,00
Johannesburg	10,00	10,00	0,01	10,00	7,50	10,00	10,00	10,00	10,00	0,01	8,00
Newcastle	10,00	0,01	0,01	10,00	5,01	10,00	10,00	10,00	10,00	10,00	10,00

Table

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Cities	Smart mobility $I_{SM}=[(I_{PT}*I_{CL}*I_{BS}*I_{CS}*I_{PMSS}*I_{PTSS})^{\wedge(1/6)}$						
	I_{PT}	I_{CL}	I_{BS}	I_{CS}	I_{PMSS}	I_{PTSS}	I_{SM}
Paris	5,31	1,90	9,28	6,62	10,00	10,00	6,29
Lyon	8,38	8,16	5,42	1,01	10,00	10,00	5,78
Freiburg	5,27	6,14	0,20	6,42	10,00	10,00	4,00
Toulouse	2,15	4,94	5,69	0,68	7,50	8,00	3,68
Amsterdam	3,49	2,23	1,01	3,29	10,00	8,00	3,57
Copenaghen	7,15	3,40	0,15	2,52	10,00	10,00	3,12
Stuttgart	6,62	0,94	0,36	5,52	7,50	10,00	3,12
Pittsburgh	5,70	1,45	0,76	1,23	10,00	10,00	3,02
Turin	5,93	0,98	0,97	1,08	7,50	10,00	2,77
Barcelona	9,78	0,25	2,71	0,60	10,00	10,00	2,72
Salzburg	2,09	2,09	1,18	0,19	10,00	10,00	2,15
Vancouver	4,63	2,17	0,01	10,00	10,00	8,00	2,08
Cagliari	**1,79**	**1,51**	**0,31**	**0,46**	**2,50**	**8,00**	**1,40**
Lecce	0,67	1,29	0,43	0,38	5,01	8,00	1,34
Treviso	1,73	2,39	0,83	0,01	7,50	10,00	1,14
Curitiba	6,19	0,25	0,28	0,05	7,50	10,00	1,09
Piacenza	1,20	2,25	0,25	0,01	2,51	4,01	0,62
Newcastle	0,53	2,04	0,02	0,01	5,01	10,00	0,46
Johannesburg	0,41	0,54	0,01	0,01	7,50	8,00	0,33