

# Mobile Phone Data in Reading Mobility Practices

Fabio Manfredini, Paola Pucci and Paolo Tagliolato

**Abstract** This chapter explores the potential of mobile phone data in reading urban practices and rhythms of usage of the contemporary city. Presenting the results of two researches, promoted by Telecom Italia and carried out by the authors, the chapter will show how new maps based on mobile phone data analysis can represent spatialized urban practices, providing new insights into space-time patterns of mobility practices. Mobile traffic data employed in the analysis of complex temporal and spatial patterns (Erlang, and origin–destination matrices) were treated as the effect of individual behaviours and habits, offering information about the features of usage of urban spaces that vary over time. Thanks to the processing of mobile phone data, it was possible to describe the intensity of use of the city (during the day, weekdays/holidays, seasons), linking them to the differences in the distribution of urban activities at different hours, day and weeks, as a useful tool to define urban policies regarding the supply of services; managing large and special events (inflow, outflow, monitoring), also estimating the mobility demand and the spatial-temporal variation in population density; describing time-dependent phenomena that are missing from traditional analysis; as well as tracing ‘fuzzy boundaries’ as perimeters of practices, as a tool for supporting and increasing the efficiency of urban policies and mobility services.

**Keywords** Erlang mobile phone data • Origin/destination mobile data • Treelet approach • Daily practices • Urban policy

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Specific credits: Paolo Tagliolato paragraphs 1 and 2, Fabio Manfredini paragraph 3, Paola Pucci paragraph 4.

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## 1 Introduction

In “The computer for the twenty first century” Weiser (1999), leader of the “ubiquitous computing” programme at Xerox Palo Alto Research Center, anticipated how a new generation of computers in the next few years would be so intimately interlaced in people’s daily life as to become invisible to our perception. The main features of this kind of computers, according to Weiser, are their knowledge of their own location and their reduced size. At PARC, some prototypes of these devices were constructed and their resemblance to our smartphones and tablets is amazing.

The wide diffusion of smart devices that make the internet available “on the move” opened up new perspectives for information collected by people. This is the case of volunteered geographic information (Goodchild 2007), where citizens become “sensors” and can contribute to the collection of geographic data. Smartphone applications, open data portals, citizen science initiatives and social networks constitute the current scenario in this direction: with a few taps on a smart device, it is possible to enrich the current state of knowledge of places with regard to manifold topics, from the presence of biological species to leisure places in a city, from agronomy to road traffic.

Besides, crowdsourced big data suffer from the reliability of collected data: their accuracy is a fundamental issue. Coming to the possibility of exploiting this information for urban studies and mobility, whose appeal, given the costs of traditional surveys, undoubtedly emerges, the works in this direction must cope with the serious issue of the bias in the kind of people effectively using these technologies.

Despite this, in the same increasing trend of mobile communication, the so-called “next social revolution” (Rheingold 2002), a different source of data offered by people acting as sensors, but less prone to biases, has developed over the years: data are cellular network data, collected by providers for technical and accounting needs, a continuously updated source of information about the usage of mobile phones. In this case, with regard to the representativeness of cellular network data with respect to people, we can consider how mobile phone technology has been increasingly adopted by people in the past years: the average mobile penetration rate had increased from 0.4 % in 1991 to 91.1 % by 2010 worldwide (according to the World Bank) and in Italy in 2010 it was 146 %.

Mobile phone traffic data are promising sources for large-scale surveys. Users provide information about the (use of the) territories by simply using their mobile phone. Moreover, these data are automatically generated from the telecommunication networks, so there is no need for the huge investments necessary for acquisition of traditional data banks.

## 2 Analysis of Cellular Network Data

In the context of a collaboration with Telecom Italia,<sup>1</sup> one of the main cellular network providers in Italy, we carried out a project studying the potential and usefulness of cellular network data for urban studies and mobility. The main source maintained by cellular network providers is the “Call Detail Records” database. A call detail record reports, for each mobile phone call, the identifier of the mobile device (more precisely that of its SIM card), the cells in which the call occurred and timestamps of start and end of the call. The big issue, when exploiting these data, is privacy: it was proven (De Montjoye et al. 2013) that, even if anonymized (for instance obfuscating the ids of SIMs), these data can be used to identify people, being spatial traces of at least four spatio-temporal points, a unique fingerprint.

In the light of this consideration, we wish to point out that we only considered aggregated data, intrinsically and effectively characterized by anonymity, and hence, in our opinion, data that could be practically used for real applications.

In our study, the available data were processed following a methodological approach outlined in Fig. 1.

We present here just two data elaborations, given their particular relevance to spatial mobility.

The first data type regards the cellular network traffic intensity spatially distributed over the Lombardy region. It is expressed in Erlang, a dimensionless unit used in telecommunications as a measure of the average number of concurrent contacts in a time unit. Even if it can be derived from Call Detail Database, these data were directly collected at the antenna level, without relation to single users. It can be thought of as the work of the antenna, reporting the number of calls managed by it in a time unit. Starting from the traffic recorded by each antenna, the provider distributed the measurements, by means of weighted interpolations, throughout a spatial tessellation of the region in  $250 \times 250 \text{ m}^2$  areas (“pixels”). The data at our disposal covered the period 2009–2011. We used for the analyses the ratio between the amount of Erlang in each pixel and the total amount of traffic, at the same moment, in the “universe”, represented in our case by the Lombardy Region. This relative measure indicates the amount of telephone traffic in a certain spatial region with respect to the total traffic. These data are more likely to provide indirect information about variations in the number of people. The information was statistically processed for comparison with the variables derived from consolidated data sources (census data, land use). These data were used to evaluate the possible relationships between variations in the intensity of cellular network phone calls and land-use characteristics.

Comparing Erlang data and data of people’s presence in the Lombardy region derived from the latest official survey on mobility (Indagine O/D Regione

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<sup>1</sup>Two research projects were financed by Telecom Italia during the year 2009 and 2011: “Utilizzazione dei dati di telefonia mobile per indagini territoriali” and “Stima di Matrici O/D con dati di traffico telefonico”.

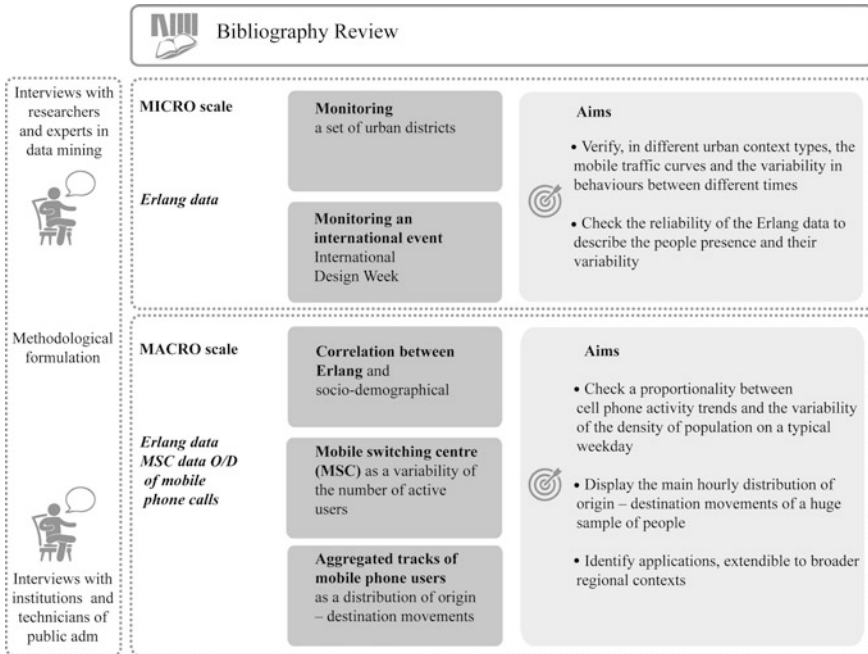


Fig. 1 The methodological approach (Source Pucci et al. 2015)

Lombardia 2002), we found a high correlation at the municipal scale (Pucci et al. 2015, Sect. 3.2.1 for a broader discussion), confirming the reliability of cell phone traffic data. The following table presents the correlation coefficient for the provincial capitals of the region (Table 1).

Erlang measures can give insights into various aspects of the urban area to which they refer, and analysis of them can be developed for various purposes, including selection of urban zones from the observed area with particular traffic intensity, identifying and measuring the attractiveness of the areas and their variability during the day; identification of “anomalies” occurring in the use of certain areas in reference to land uses, population and activity densities; monitoring of large events taking place in the city; segmentation of the area into districts characterized by homogeneous telephonic patterns; and identification of a set of reference signals able to describe the different patterns of utilization of the mobile phone network in time.

We discussed these topics and our results in (Pucci et al. 2015). Here, we only present one elaboration based on an analysis of the spatial and temporal variability of urban spaces during a large-scale event—called the “Salone Internazionale del Mobile”—which takes place not only in a specific part of Milan—the Rho-Pero exhibition district—but also in different parts of the city of Milan with various initiatives—going under the name of “Fuorisalone”.

**Table 1** Linear correlation between the time series of cell phone traffic and those of people’s presence in the provincial capitals of Lombardy region

Municipality	$\rho$ (Pearson’s correlation coefficient)—original time series	$\rho$ —moving average (3 terms) smoothing of the time series	$\rho$ —moving average (3 terms) smoothing of the time series, time range 07:00–23:00
BERGAMO	0.817281	0.916167	0.937125
BRESCIA	0.845554	0.941575	0.968859
COMO	0.670492	0.902546	0.930791
CREMONA	0.783395	0.974567	0.986318
LECCO	0.761152	0.891482	0.920895
LODI	0.825717	0.928989	0.982498
MANTOVA	0.483841	0.773677	0.939052
MILANO	-0.269416	0.453118	0.878923
MONZA	-0.321579	0.935640	0.978077
PAVIA	0.292641	0.835625	0.874587
SONDRIO	0.739026	0.862859	0.919483
VARESE	0.895775	0.969681	0.986226

Source Pucci et al. (2015)

This event attracted temporary populations that are difficult, if it not impossible, to measure with traditional data and surveys, but detected by mobile phone network data, as shown in Fig. 2, where the activity in the city of Milan in an average working day and the activity in a specific day during the International Design week are compared.

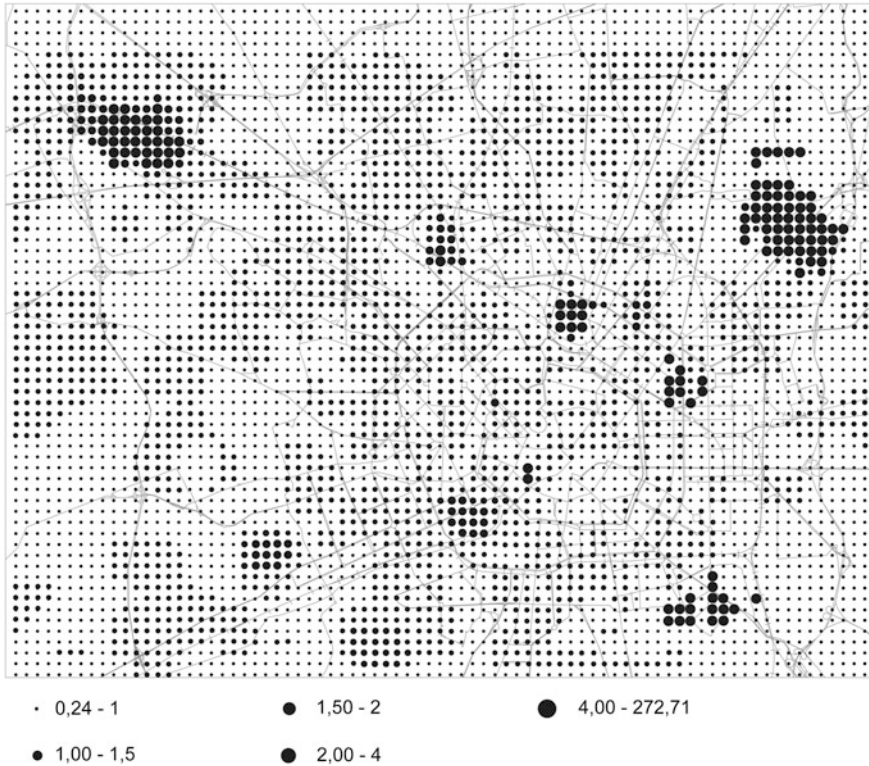
Values are ratios of telephone traffic among these days. Areas with events associated with the large event clearly emerge with values indicating an activity three times the normal. Such kinds of maps (specific day/average day) could easily be derived daily, and could be a tool for monitoring anomalous concentration of activities.

Figure 3 shows the outcome of a more sophisticated technique, Treelet decomposition (Lee et al. 2008) of Erlang signal, which can give insights into hidden patterns of mobile phone usage, caused by different usages of the city in time and in space which are related to individual mobility (Manfredini et al. 2012a, b, 2015; Vantini et al. 2012; Pucci et al. 2015).

In Fig. 3, each map in the set shows the intensity of specific patterns of both mobility and city usages (commuting, nightly activities, distribution of residences, non-systematic mobility), comparing them with the main urban facilities and services.<sup>2</sup>

In doing so, the Treelet approach shows the ability of mobile phone data to reflect the space-time variability of use of urban spaces, not necessarily due to the functional features, land use or the times of the activities, but rather to the ways in which people frequent some of these spaces.

<sup>2</sup>In each map, we added infrastructures (railways and main roads), railway stations, Linate city airport, main shopping centres and the fair trade centre.

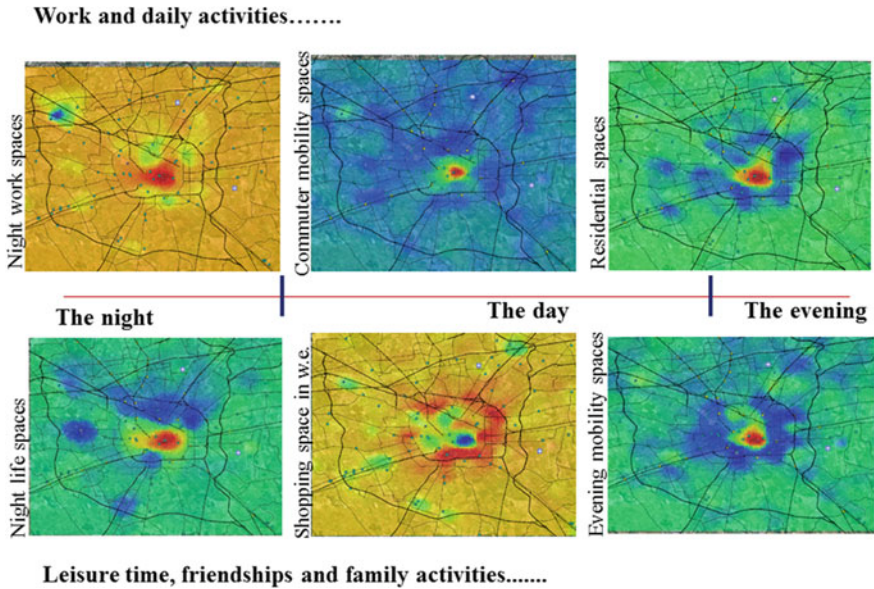


**Fig. 2** Cell phone traffic intensity ratio between a day during the International Design Week, 2009, and the average working day. The map highlights the parts of the city where the activity, during the International Design Week (April 24), was greater than during a typical weekday

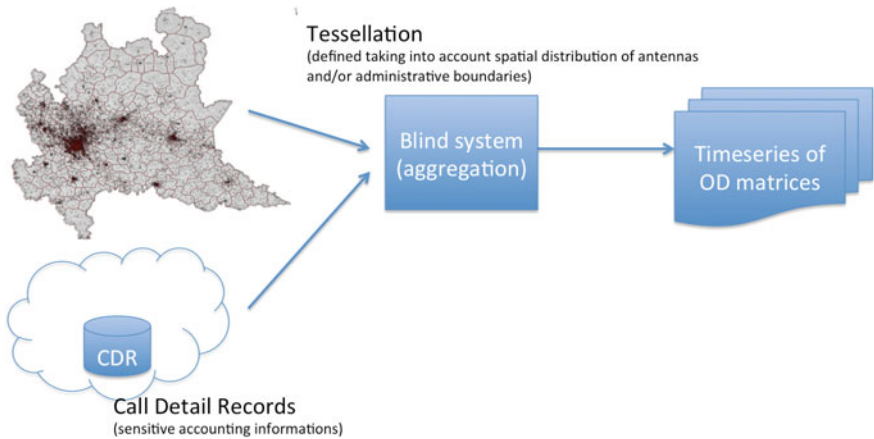
This outcome is very promising for urban studies because it enables us to describe the “urban rhythms” generated by practices, rather than defined by opening/closing of activities, and to work with the actual uses of the urban spaces and services, as experienced in urban practices.<sup>3</sup>

The second typology of data is the aggregated origin–destination flows derived from the call detail records database. In the framework of our research and in collaboration with Telecom Italia (T-Lab), we arrived at a definition of a datum which was free from privacy restrictions, consisting in an aggregation of users’ movements based on CDR records. Telecom Italia implemented a system for automatic, blind extraction of data of this kind, depicted in Fig. 4. Once fed with the CDR and a tessellation of a geographical region, it outputs time series of origin–destination matrices (where origin and destination zones are the tessellation tiles), equivalent to a function  $F(o, d, t) \rightarrow n$  which, at time  $t$  ( $t$  varying in the 24 h of a

<sup>3</sup>For more extensive discussion, we refer the interested reader to Pucci et al. (2015).

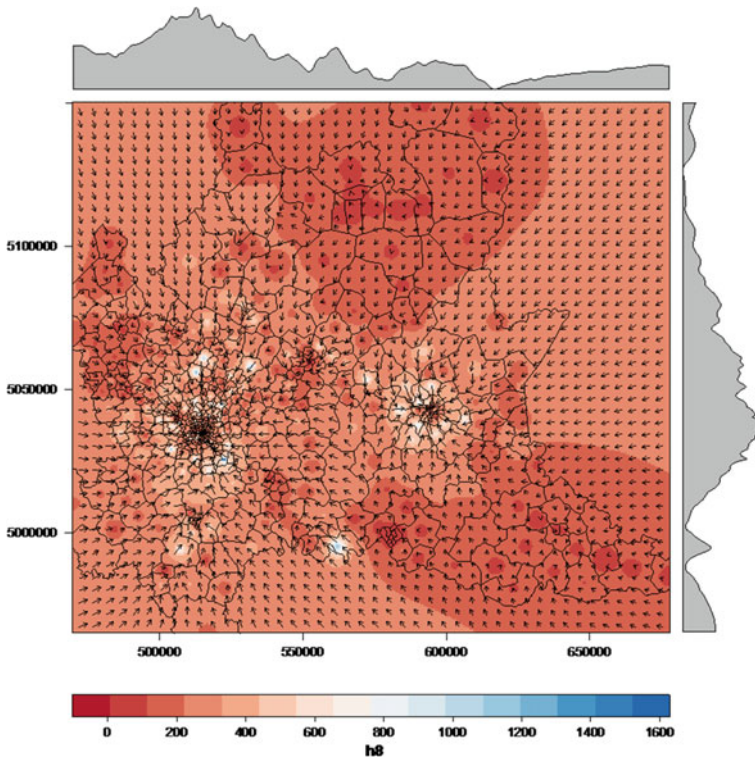


**Fig. 3** Urban practices through mobile phone data. *Source* processing by DASTU (Dipartimento di Architettura e Studi Urbani) and MOX (Laboratorio di Modellistica e Calcolo Scientifico)—Politecnico di Milano, on Telecom Italia data, 2013



**Fig. 4** Blind extraction of time series of aggregated origin–destination matrices

given day), assigns to origin  $o$  and destination  $d$  the number  $n$  of distinct users that performed some mobile phone activity within  $o$  at time  $t - 1$  and a subsequent activity within  $d$  at time  $t$ .

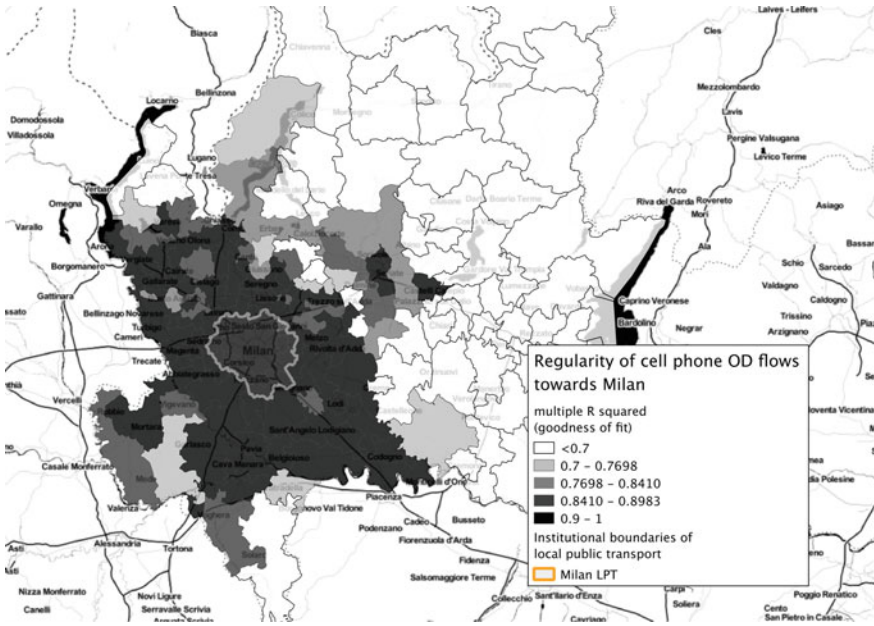


**Fig. 5** Vector field of prevalent flows of mobility obtained through kriging

We proposed an overview of these data in terms of “prevalent flows” of mobility, defined as the sum vector of all the flows of people moving from each zone. Figure 5 shows the result of interpolating the sum vectors to obtain a regular vector field. In particular, the figure depicts the vector field for the morning rush hours in the Lombardy region. The polarization of movements towards the two cities of Milan and Brescia appears quite clearly.

Further, we showed by means of more sophisticated analysis (Tagliolato et al. 2014; Pucci et al. 2015), how this kind of aggregated OD matrices can be informative for. We identified pairs of zones with a high degree of regularity of movements between them. Public transport policies could benefit from identification of regular mobility practices: it could offer insight into the actual catchment area of an urban context, to which regulation measures and appropriate rates of the public transport service should correspond.





**Fig. 6** Regularity of flows directed towards Milan. The perimeter of the institutional boundaries of the management of the local public transport is superimposed (Source Pucci et al. 2015)

We considered, for each origin–destination (od) pair, the seasonal process

$$\Phi_{od}(t) = \sum \beta_i D_i(t) + \varepsilon(t)$$

where the sums are taken on  $i$  varying in  $\{1, \dots, 24\}$  and the  $D_i$  are seasonal (i.e. hourly) indicator variables, and we calculated the coefficient of determination (multiple  $R^2$ ) that results from fitting  $\Phi_{od}$  to  $F_{od}$ .  $R^2$  measures the quality of the model fit: we take it as a synthetic indication of the regularity of the signal.

Figure 6 represents in this perspective of regularity of movements a “catchment area” of Milan, alternative to the superimposed Local Public Transport institutional boundaries. Identification of the actual boundaries of the provenience of temporary populations of the city could contribute to the definition of fairer and more efficient policies (Pucci et al. 2014).

### 3 Towards a Role of Mobile Phone Data in Official Statistics

In our research, we demonstrated how different types of cell phone data can provide new knowledge about urban dynamics, which can be used in practical terms.

These data, thanks to their spatial and temporal resolution, appear to have great potential in urban analysis and planning, in particular for recognition and identification of urban practices occurring in time and space. These phenomena are difficult to recognize through conventional data sources since they are rarely updated and since they are not able to intercept phenomena which change over time such as typically, mobility or the temporary presence of people in certain parts of the city, or the density of uses of territories.

Recent years have seen a growing debate on evaluation of the potential contribution of new sources of data based on information collected anonymously by users to official statistics.

In particular, the main question is definition of methods able to integrate them with conventional data sources to overcome the limitations of conventional data in describing and measuring phenomena occurring in urban spaces.

Among these urban phenomena, mobility in its spatial and temporal articulation appears to be one of the main issues that call for identification of new sources of data and methodologies able to describe it.

The perspective opened by mobile phone data in this field is particularly interesting if we consider, for example, the situation in the Lombardy region and focus on the following points (Pucci et al. 2015, p. 55):

- the spatial resolution of mobile phone data is, in urban areas, much finer than that of traditional surveys. Mobility practices can, then, be better visualized and studied;
- mobile phone data are continuously collected and their temporal resolution is very high; it could be possible to monitor different practices over time on an hourly, daily or seasonal basis;
- the transport mode is lacking in mobile phone data, which means that only indirect indications can be obtained for traffic on the main roads;
- we may reasonably assume that when information derived from mobile phone data becomes available on the market it will cost rather less than the outlay needed for conventional surveys, the mobile phone data having already been collected for accounting and for network monitoring (Table 2).

These mobile phone origin–destination data have much to offer for investigations into mobility and for urban analysis, in general.

If we consider mobility in a wider sense, not only related to origin–destination data, but also to the density of uses of the territories, we can compare other types of data (i.e. Erlang data) with conventional data sources in order to evaluate the potential of this kind of data in analysing urban phenomena (Table 3).

In origin/destination mobile data, information about users (user sociodemographic profiling, purpose of trips, modes of transports) is missing, and moreover there are sampling issues (data provided by one company, data on mobile phone activity, just to cite two major concerns).

The potential availability of these data opens new implications for the urban research community that needs to elaborate new strategies to integrate traditional data with user-generated data, such as mobile phone activity, in order to achieve a better comprehension of urban usages, in time and in space.

**Table 2** Comparison of the available sources on mobility in Lombardy

	Survey on mobility (OD) Lombardy region 2014	Census (on commuting) ISTAT 2011	Mobile phone data (aggregated O/D tracks)
Sample	30 K interviews	All residents	Mobile phone users ~1.5 M per day
Type of movement	All	Study and work	All
Reference period	Average working day in 2014 (February–May)	Typical working day	Everyday
Updates	Expected on an yearly basis from 2016	Every 10 years	Continuous
Information on vehicle	Yes	Yes	No
Spatial resolution	Municipalities, aggregation of minor municipal districts, subdivision of major municipalities	Municipalities	Variable aggregation of cells
Temporal resolution	24 h	7–10 a.m.	Hourly or sub-hourly
Cost	Expensive	Very expensive	Not known

**Table 3** Comparison between conventional data sources and mobile phone data

	Conventional data sources (municipal statistical offices)	Conventional data sources ISTAT census	Mobile phone data (Erlang)
Sample	All residents	All residents	Mobile phone active users
Spatial resolution	Urban blocks	Municipality boundaries (very variable), urban blocks	Pixel size 250 × 250 mt
Reference period	Yearly	2011 (census)	Everyday
Updates	Yes (yearly)	Every 10 years (census)	Continuous
Available information	Number of inhabitants, sex, age, nationality	Number of inhabitants, sex, age, nationality, workers, education, employees, etc.	No
Temporal resolution	Yearly	Yearly	Hourly or sub-hourly
Data ownership	Public	Public	Private
Cost for the production	Expensive	Very expensive	Not known, cheap
Cost for the public	Free	Free	Not known, not free

At the same time, official statistics are therefore required to interact with this new kind of data, in order to evaluate if, and if so how mobile phone data can be used as new sources, able to describe phenomena for which official statistics do not collect data. In doing so, digital data as additional sources can be used as complement to conventional data sources or as alternative sources able to replace conventional ones (Barcaroli et al. 2014).

Questions that need to be addressed are the possibility and the expediency to replace existing data with mobile phone data or to improve/validate/integrate existing data with new sources and the possibility to collect completely new data about aspects of social life that are hard to capture with conventional data sources such as specific groups of populations, time-related information, etc.

In this direction, UNECE—United Nations Economic Commission for Europe—decided to set up an internet inventory on the use of Big Data in national and international statistical organizations (<http://www1.unece.org/stat/platform/display/BDI/UNECE+Big+Data+Inventory+Home>).

The inventory contains structured and searchable information about actual and planned use of Big Data in statistical organizations. This information is held in a standard template, searchable by statistical domain (using the Classification of Statistical Activities, an existing international standard), and the classification of type of Big Data (developed by the Big Data Task Team).

Among these, some are related to the use of mobile phone data, in particular concerning mobility issues and tourism. For each project, the major findings and problems are summarized. One of the main issues is privacy. While mobile phone operators have potentially access to all the information about their customers (mobile phone activity, location, direction of communications), they may not give the same access to researchers or official statistics institutions, depending on their company privacy policies and on the laws on protection of privacy in the country of application (Blondel et al. 2015).

The anonymization of mobile phone data is a growing field of research because the possibility to use these data for purposes other than those for which they are originally collected emerged only a few years ago. Moreover, the attention of public opinion to these topics must be kept in absolute consideration.

At the same time, the formats in which the data can be provided are many and there is not yet an established standard of mobile phone data free of privacy constraints. In general terms, the original raw data are acquired automatically by the network, processed directly by the company and finally provided to the scientific community in different formats, at different spatial and temporal resolutions, and it is not always possible to obtain precise information on the methodology used for producing the data.

The data refer to mobile phone activities, i.e. the number of interactions between the device and the network (calls, text messages, etc.). Therefore, the number of active users is lower than the number of mobile phone subscriptions. In our research, we found that in the Lombardy region the number of mobile phone users with more than 8 activities per day exceeded 1 million, which is in any case a value greater than the dimension of a standard statistical sample defined in the framework of a survey.

Despite the limitations to the quality and nature of the data, we must stress that the sample size is comparable, if not greater, than that of many conventional surveys based on interviews.

There is a trade-off between the completeness of the sample achievable with census data versus the variability of the number of active users in mobile phone data. There is also another trade-off in the spatial and temporal resolution of mobile phone data, measurable, respectively, in hundreds of metres and in minutes/hours, in comparison with the spatial and temporal resolution of conventional data, measurable, respectively, according to the dimensions of administrative or statistical units and in years.

By choosing one source rather than another, we lose some information, gain some other information and the researcher has the responsibility to explain the limitations and the advantages to final users and urban stakeholders.

The census data output is usually coarse in resolution (e.g. local areas or counties rather than individuals or households). Moreover, the methods used to generate the data are quite inflexible (for example, once a census is being implemented, it is impossible to add/remove questions). Whereas the census seeks to be exhaustive, enumerating all the people living in a country, most surveys and other forms of data generation are samples, seeking to be representative of a population.

Mobile phone data have a very fine spatial and temporal resolution and are very flexible. It is therefore feasible to analyse customized areas depending on the aims of the research (urban blocks, linear infrastructures, etc.). Precise spatial accuracy is therefore one relevant aspect that creates greater possibilities for detailed research.

Another point to stress is that mobile phone data must be interpreted, even with the help of conventional data sources (e.g. mobility data, land use/land cover, sociodemographic data, census data) and other sources that have become available in recent years (open mapping websites, social media data and in general user-generated data). This is important because, thanks to a map of activities, land cover or urban facilities, it is possible to attribute a sense to concentrations and hot spots of mobile phone activity or anomalies in specific hours of the day, days of the weeks and seasons.

Mobile phone data are therefore important as corroborating evidence in explaining patterns of usage of the city by urban populations (Pucci et al. 2015, p. 75).

In this context, the official statistics institutions can play a relevant role in incorporating some of the methodologies and of these new sources of data in their own tasks. First, they can act as public interlocutors of telephone companies in order to define formats and conditions to obtain mobile phone data for the general interest. In fact, since mobile phone companies are private, no technical and scientific collaboration between them exists, with the exception of some humanitarian projects in Asia or Africa. In this framework, the definition of a public interest use of mobile phone data and the identification of a public agency (i.e. an official statistics institution) may lead companies to share some data for specific purposes.

Moreover, using data at high temporal and spatial resolution, it will be feasible to move from descriptive indicators to statistical modelling (nowcasting and forecasting) and to integrate, in the general framework provided by conventional data, the outcomes derived from the analysis of spatial and temporal patterns of mobile phone data.

Selection of research experiments on the integration of different datasets, identification of replicable research methodologies and definition of a protocol to integrate heterogeneous information could be three relevant tasks for the development of applications of mobile phone data to specific case studies.

Statisticians, social scientists, urban planners and geographers should take advantage of this new data source. Due to their complexity, integration between different competences is needed to fully exploit the potential of this kind of data. Computation and quantitative analytical skills are therefore required, together with the capacity to read and visualize spatial-temporal dynamics deriving from the analysis of big data.

Analysing the spatial and temporal usage of cities in their contemporary daily-life practices requires integration between traditional data (land cover, town plans, spatial distribution of activities, etc.) and new sources of information, closer to users, such as mobile phone data activity or geolocated digital traces, with the aim of identifying the complexity and multiplicity of individual behaviours. Through the new data, we can define who we are by the places we go to, overcoming some limitations due to characteristics of traditional sources of data in describing contemporary city dynamics.

In this context, the real challenge for urban studies is the integration of available databases together with an innovative use of traditional sources, in order to capture the variety of changes in urban practices (Pucci et al. 2015, p. 76).

## 4 Towards a Role for Mobile Phone Data in Urban Policy

The processing of mobile phone data has an important role to play in both the analytical and the normative dimensions of urban policies, within two complementary perspectives.

The first perspective appraises the relevant real-time knowledge offered by mobile phone data in describing the intensity of urban activities and their evolution through space and time, as a framework for area-wide implementation of more effective urban and mobility policy.

This is because, as effect of individual behaviour and habits (Ahas and Mark 2005), mobile phone data enable us to detect the molecular daily practices and the emerging demands being made by populations using the city and its services, at varying rhythms and intensities.

These potentialities are related to the peculiar features of mobile phone data. Indeed, although “certain footprints have a personalised value (...), they indicate the presence of a person implied from the outset”<sup>4</sup> (Ferraris 2009, p. 336), in our research these “idiom footprints” are not connected to an individual, but instead to

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<sup>4</sup>My translation of “Certe tracce possiedono un valore individualizzante [...] ossia segnalano la presenza di una persona che ne è all’origine e che vi è implicata” (Ferraris 2009, p. 336).

“groups of subjects that, temporarily and intermittently, share practices of daily life” (Pasqui 2008, p. 148). This is because the nature of the data provides aggregate behaviours related to the intensity of mobile phone use. In doing so, our research focused on the longitudinal activity patterns of network cells rather than individual users. Through geographical mapping of mobile phone usage at different times of the day, it was possible to verify the value of these data to ascertain the following:

- population distribution in cities and their variability, according to the density of call activity in mobile network cells;
- land-use classification according to mobile phone uses, in which different “basic” profiles of city usages can concur to identify different profiles of use and consumption without the burden of a direct survey; in this case, mobile phone data would allow for functional description of space in terms of effective uses instead of activities and equipment<sup>5</sup>;
- origin–destination tracks of mobile phone users in the form of an O/D matrix to monitoring different mobility practices over time, on an hourly, daily or seasonal basis.

Thanks to the potentialities of mobile phone data in explaining the spatial dimension of varying practices that have great impacts on the densities of use of the city and its services, we can propose several possible applications in terms of the following:

- recognizing specific (in time and space) situations of deficit in public transport supply related to the effective concentration of population and uses;
- supporting and increasing the efficiency of urban policies and transport services with more detailed knowledge of the intensity of the use of the city (during the day, weekdays/holidays, seasons) linking them to the differences in the urban activity distribution at different hours, days and weeks;
- managing environmental and industrial risk protection with information deduced from mobile phone data used as a “proxy” of the population exposed to specific risks;
- managing large and special events (inflow, outflow, monitoring), also estimating the mobility demand and the spatial-temporal variation in population density, to offer guidance for future decisions on the provision of new urban services;
- developing an integrated research protocol based on the comparable and available data (traditional and digital data) and starting from definition of the main indicators, measures and successful criteria to be implemented at the local scale for the Local Authorities.

Far from seeking a deterministic analysis that allows for continuous real-time calculation, referred to by Nigel Thrift as “qualculation” (Thrift 2004), we know that “research is needed to understand the policy implications of these data and how institutions should evolve to accommodate them. Methodologies and tools are

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<sup>5</sup>See Chap. 3 in Pucci et al. (2015).

needed for devising effective policies, combining them strategically and overcoming implementation barriers such as public and political acceptability” (Bruun and Givoni 2015, p. 31). In addition, the outputs must be comprehensible to elected officials and, indeed, to the public.

However, an essential condition that makes these data particularly interesting for urban policy is linked to the importance of taking the urban rhythms in exploring the complexity of the contemporary city where the increase of “polyrhythmic nature of everyday urban life” needs new analytical approaches.

If “the urban has an intrinsically rhythmic organization which, in turn, gives rise to specific forms, configurations and relations of space, time, interaction and mobility” (Smith and Hetherington 2013, p. 6), it is through more effective analytical tools such as mobile phone data that the rhythmic organization of the city can be read.

Our references take into account that the contemporary city is a “site of sociability” (Amin and Thrift 2002), understanding of which is made possible by the space-time variability of the practices that take place in it. Mobile and digital data take us beyond an approach to the city as configured by “enclaves” (fixed and bounded sites) and ‘armatures’ (infrastructure channels and transit spaces) (Shane 2005), providing real-time maps of a daily practices that bring out a rich variety of places of use in accordance with the temporal organization of everyday life. These places define new geographies that call into question urban policies and transport supplies.

In addition, through processing mobile and digital data, two myths are challenged: the “death of distance” caused by mobile technology and the borderless world through space-time compression, as well as the “erratic and nomadic behaviour of metropolitan populations”. The data show a strong recursion path: while we move a lot during the day, we tend to do so along familiar and habitual paths<sup>6</sup> (Gonzalez et al. 2008).

The second perspective concerns the valuable support offered by mobile phone data in “re-scaling” urban policy and assisting in the construction of geographies of partnerships between different stakeholders.

On the evidence of several researches (Ahas and Mark 2005; Ratti et al. 2006; Kwan et al. 2007; Reades et al. 2007), mobile phone data offer multi-scalar maps to deal with the variability of the relationships, with time-dependent phenomena, with the heterogeneous rhythms of urban practices that are missing from traditional analysis, becoming a support for tracing fuzzy boundaries as perimeters of practices, useful for a “re-territorialization”<sup>7</sup> of urban policies.

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<sup>6</sup>In this perspective, the work of Gonzales, Hidalgo and Barabasi, which examined the tracked positions of individuals, demonstrated that “human trajectories show a high degree of temporal and spatial regularity” (Gonzalez et al. 2008).

<sup>7</sup>This means a process of ‘shaping’ between shifting political boundaries, new geographies and structures of power, human landscapes, local/transnational communities and their everyday border experiences.



The need to build relevant boundaries as a resource of institutional capital in Spatial Planning comes up against the difficulty of giving operational content to this issue as well as the practical impact of the shift on institutional boundaries and consolidated spaces of governmental activity corresponding to powers and strengthened responsibilities.

As we have already pointed out (Pucci et al. 2015, Chap. 5), a different articulation of skills and resources that will improve the regulation of practices and help to generate the new frameworks for institutional innovation, calls for tools to outlining relevant and shared variable boundaries. The challenge is posed in terms of interpretive tools able to recognize “soft spaces” (such as transversal spaces) and “fuzzy boundaries” (such as fluid perimeters) to manage “the permanent dissociation between citizens, inhabitants and city users characterizing all territorial governments”<sup>8</sup> (Estèbe 2008, p. 17).

In Spatial Planning as well as in Borderscape Studies,<sup>9</sup> many contributions—as pointed out by Parker and Vaughan-Williams (2012)—draw attention to the following:

- the need for an alternative paradigm for (re)thinking border politics’ (...), thinking about *alternative geopolitical visions* in which novel approaches to borders are mobilized;
- the urgency to understand that borders are also not temporally fixed;
- interrogation of the link between bordering practices and ‘the various forms of contestation and resistance’ border practices give rise to;
- the relationship between bordering processes and *the ‘where’ of the border*, that is to say its shifting and changing location (Parker and Vaughan-Williams 2012, pp. 727–733).

All these points are of great interest for urban planning in a project-oriented viewpoint, highlighting the main features of the borders as dynamic social processes, useful to deal with the governance process, to interpret and regulate the transformation processes in times, places, social life and work programmes in the contemporary city.

Indeed, in different experiences, ‘informal boundaries’ may become part of an ‘institutional landscape’, generating new models of public involvement and actions capable of intercepting and responding more effectively to the emerging social demands.

The debate on “soft spaces” as “representative of a deliberate attempt to generate new thinking and insert new models of public engagement [...]; as part of the changing institutional landscape of Spatial Planning (...) and predominately defined (or not) in a fluid fashion, and with reference to fuzziness, in order that they are

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<sup>8</sup>My translation from “Tous les gouvernements territoriaux vivent sous un régime permanent de dissociation entre les citoyens, les habitants et les usagers de la ville” (Estèbe 2008, p. 17).

<sup>9</sup>According to Brambilla (2014), Borderscape studies focus on the conceptual evolution of borders offering new perspectives to dealing with processes of ‘shaping’ between shifting political boundaries, new geographies and structures of power, human landscapes, local/transnational communities and their everyday border experiences.

more amenable to a shifting range of issues and actors involved in Spatial Planning projects” (Haughton and Allmendinger 2008) confirms this orientation.

The contents and key dimensions of these notions are gaining consensus, also in view of their fundamental characteristics, which express “the new post-devolution spaces of planning” (Haughton et al. 2010), but, at the same time, they leave open the matter of the operational impacts in terms of relationships with the formal hard spaces of governmental activity.

In the relationship between fuzzy boundaries, as new spaces of governance, and institutional spaces, the problems related to the temporal variability of the practices at the origin of the fuzzy perimeters, such as the mechanisms of political representation of communities of practice, remain unresolved.

An important aspect to drawing relevant boundaries in Spatial Planning is the capacity building of shared perimeters to promote forms of cooperation and new geographies of partnerships.

In this way, a different articulation of skills and resources, such as will improve the regulation of practices and help to generate new frameworks for institutional innovation, requires identification of flexible as well as shared boundaries.

According to Peck and Theodore (2010, p. 171), “(...) there is an inescapable need to confront new methodological challenges. Spatially demarcated forms of policy evaluation certainly will not do. New methodological strategies must be developed to expose and critically interrogate the interconnectedness of policy regimes between places and across scales”.

In this perspective and considering the main features of mobile phone data, they can contribute in supporting the cross-scalar approaches (i.e. how the variability of borders changes the social and political configurations), and indeed the nexus between everyday life-worlds, power relations and social borders.

Time-space variability of urban practices and their relevance in terms of density and repetitiveness, detected by mobile phone data, can provide a useful contribution, not only to the recognition and naming of the territories of urban practices deforming institutional boundaries, but also to a “re-scaling” of the hierarchies of intervention, and thus to the governance of dynamic processes.

In our research (Pucci et al. 2015, Chap. 5), we demonstrate the relevance of the maps produced with mobile phone data and representing the territories made by “communities of practice”, which generate contingent boundaries with a relational and variable value, on the evidence of the dynamics we plan to capture and regulate.

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